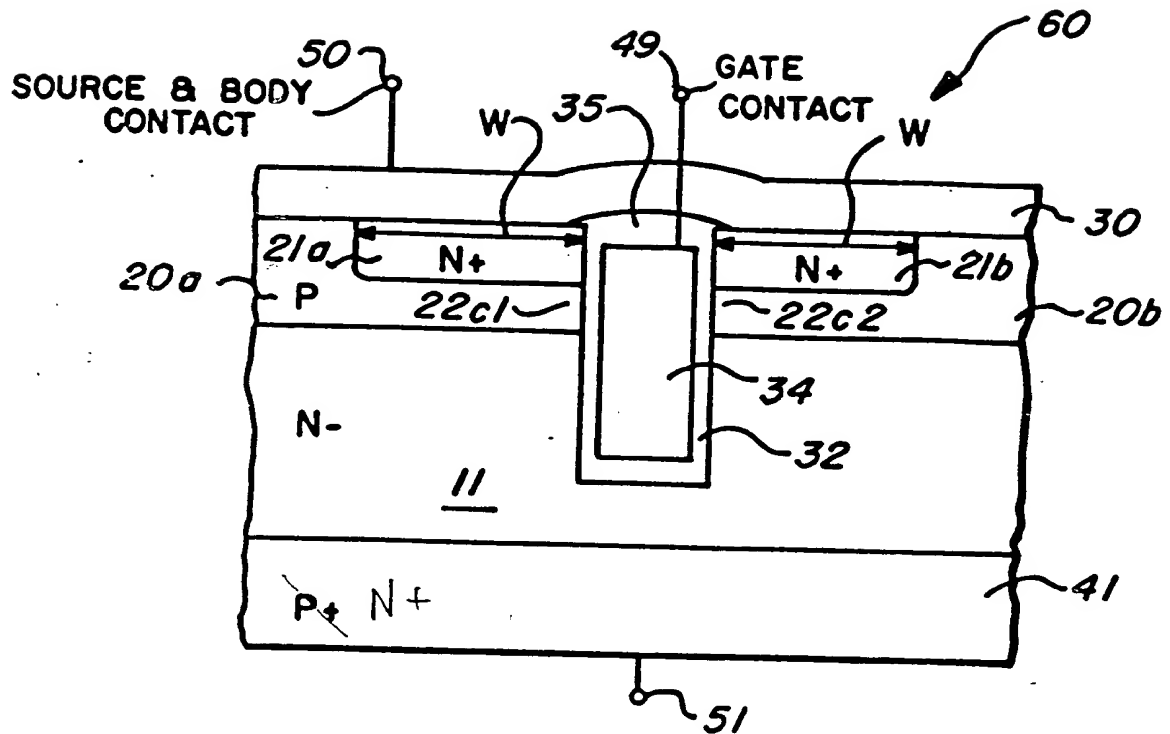


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Figure 1

Cross-section of a trench DMOS power transistor cell
 (prior art, /1,2/).

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read and understood *Randolph D. Mch* August 11, 1988

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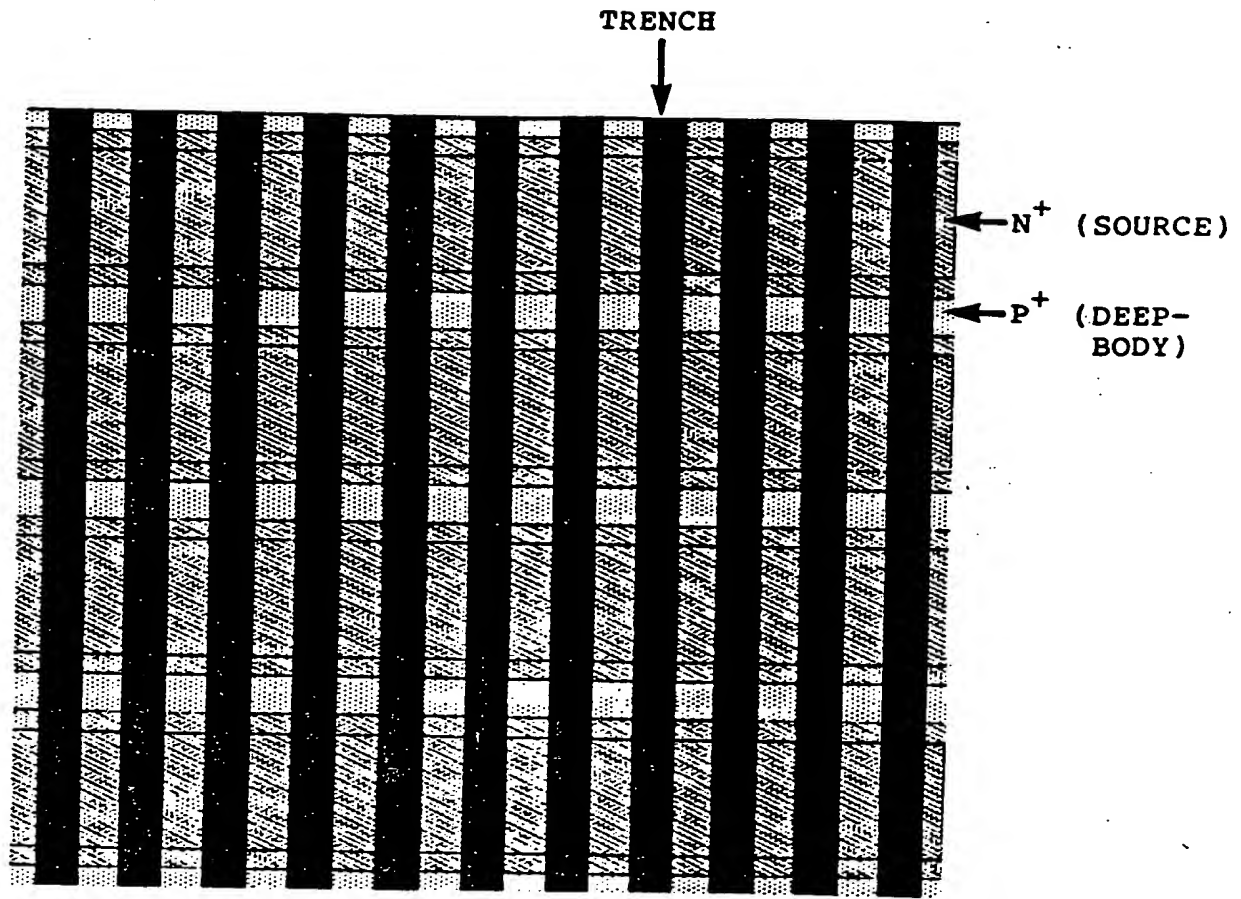


Figure 2,a

"Open-cell" implementation of a trench DMOS
power transistor (CALMA hard copy, active region).
Siliconix, Inc., 1987.

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read and understood Randolph D. Mch August 11, 1988

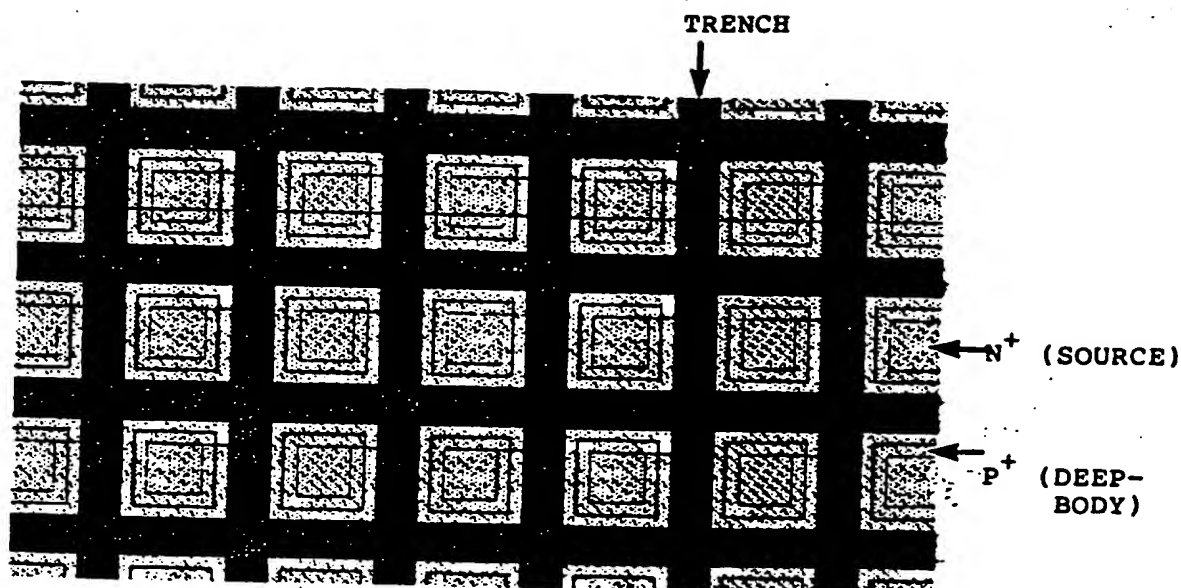


Figure 2,b

"Closed-cell" implementation of a trench DMOS
power transistor (CALMA hard copy, active region).
Siliconix, Inc., 1987.

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read and understood Randolph D. Loh August 11, 1988

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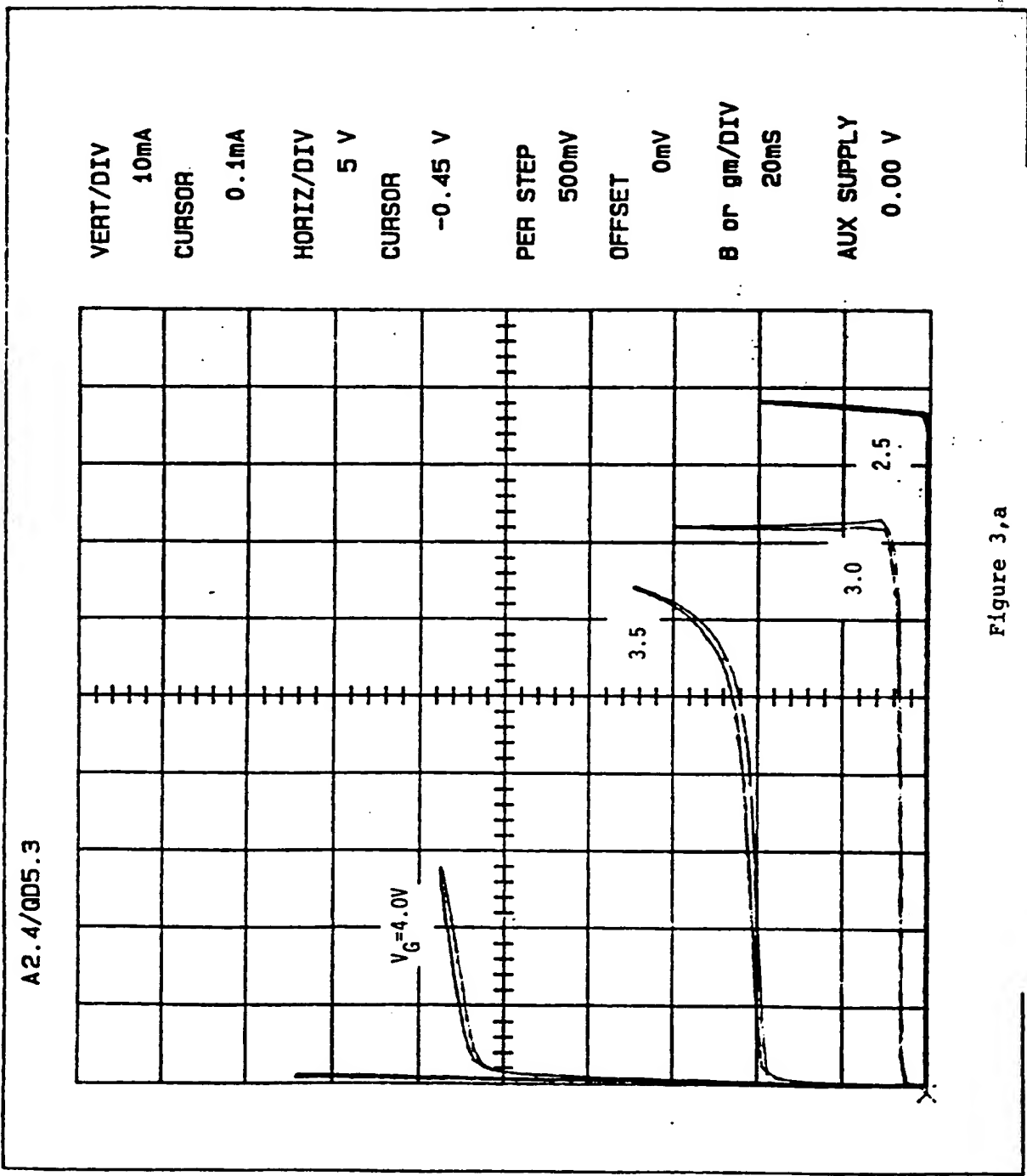


Figure 3,a

Output I-V characteristics of an experimental "open-cell" transistors having distant body contacts, perpendicular to the trenches. Siliconix, Inc., 1988.

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 read and understood August 11, 1988 R. D. L.

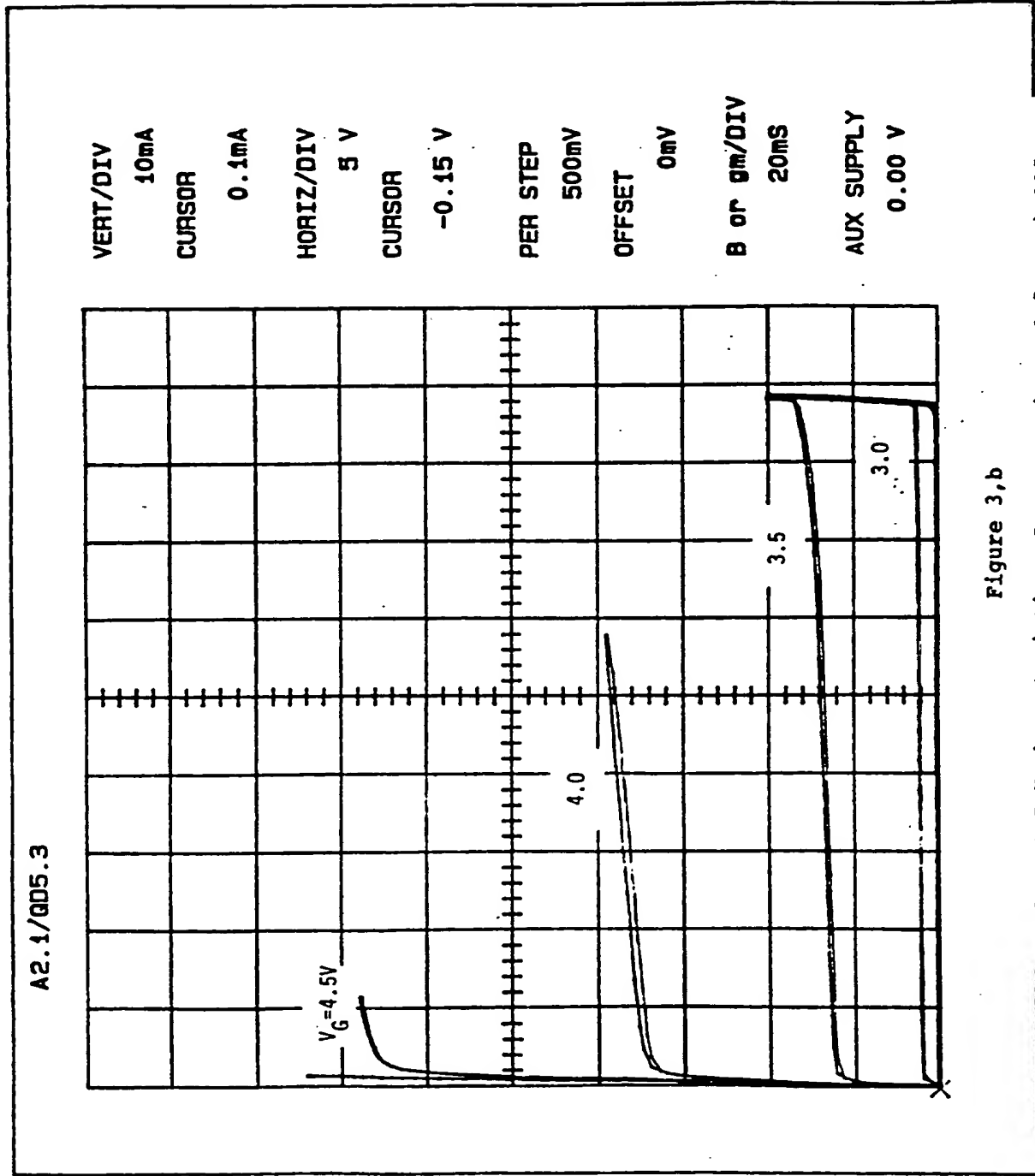


Figure 3,b

Output I-V characteristics of an experimental "open-cell" trench MOS transistor having closely-spaced body contacts, perpendicular to the trenches. Siliconix, Inc., 1988.

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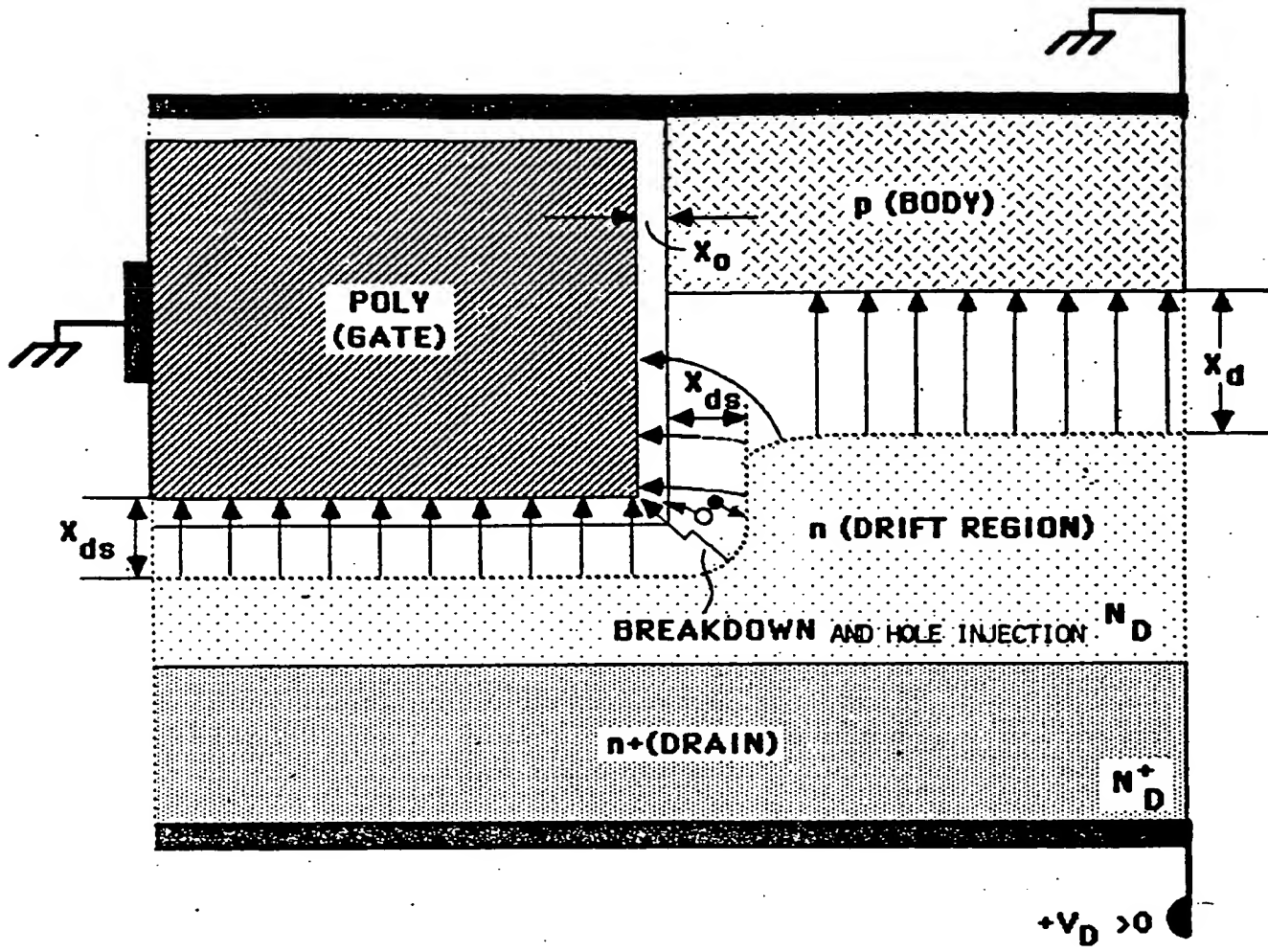


Figure 4

Qualitative description of the electric-field structure in a trench DMOS transistor having no deep-body profile provision. BVDSS biasing, source junction omitted.

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 read and understood R. D. M. August 11, 1988

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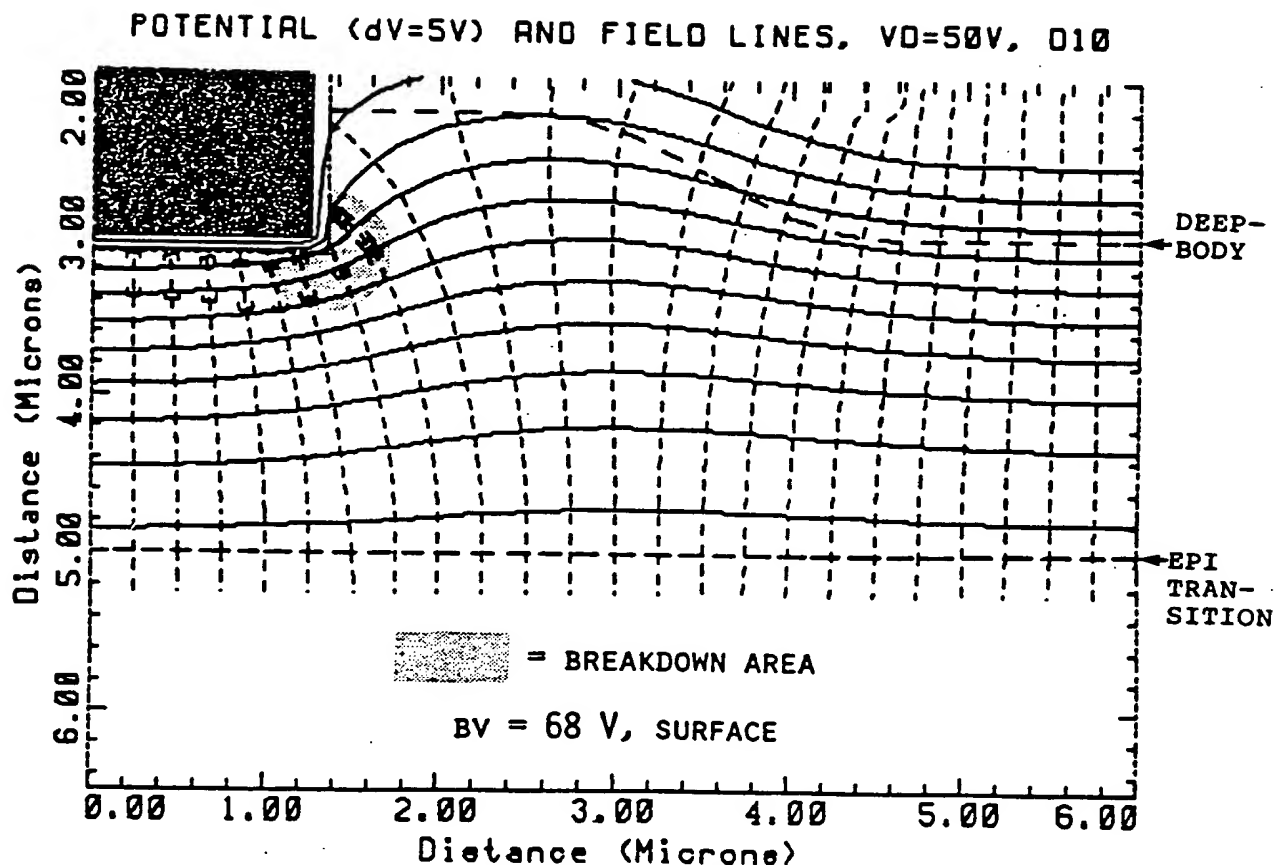


Figure 5

2-D computer simulation of the BVDSS operation of a trench MOS transistor having the deep body junction shallower than the trench. Drain breakdown takes place beneath the trench surface.

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read and understood R. L. D. August 14, 1988

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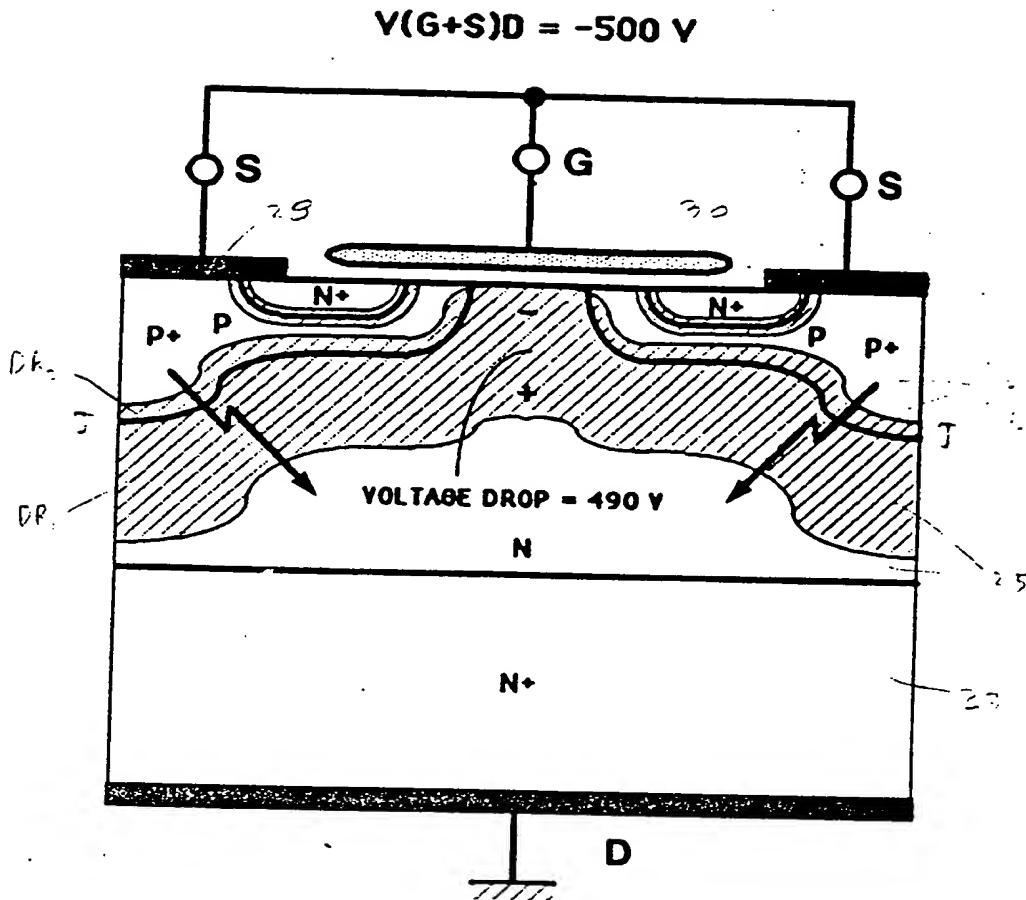


Figure 6

Junction and depletion-region topology
of a planar DMOS transistor biased in the BVDSS condition.

rec'd + as'd, t.o. Q.K.S. August 10, 1988
sent to Undersecretary Randall D. M. August 14, 1988

2-D OXIDATION SQUARE-CELL DESIGN

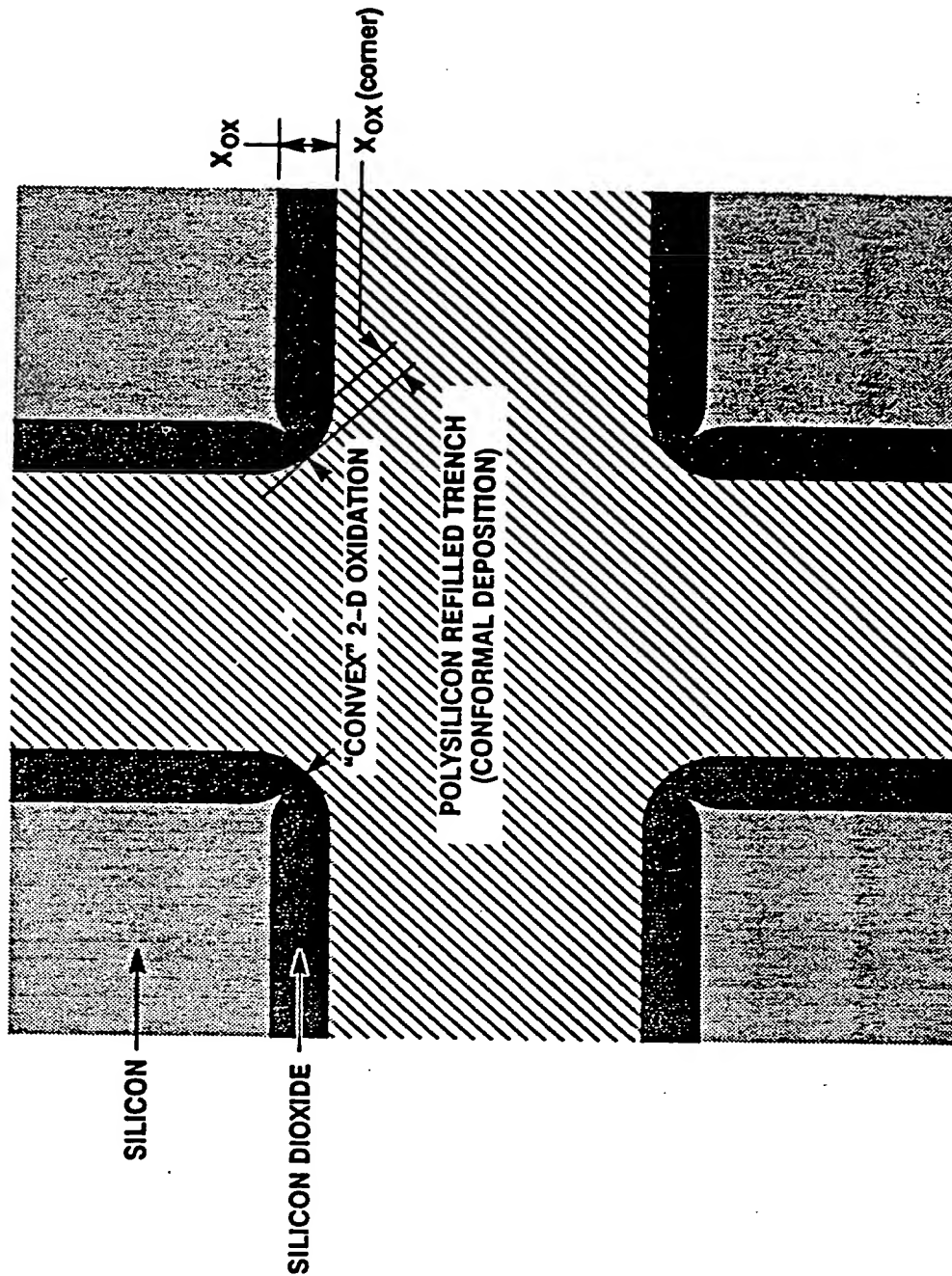


Figure 7

Qualitative description of the oxide profile
at a rectangular trench intersection.

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read and understood Paulist Doh August 11, 1988

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HEXAGONAL-CELL TDMOS

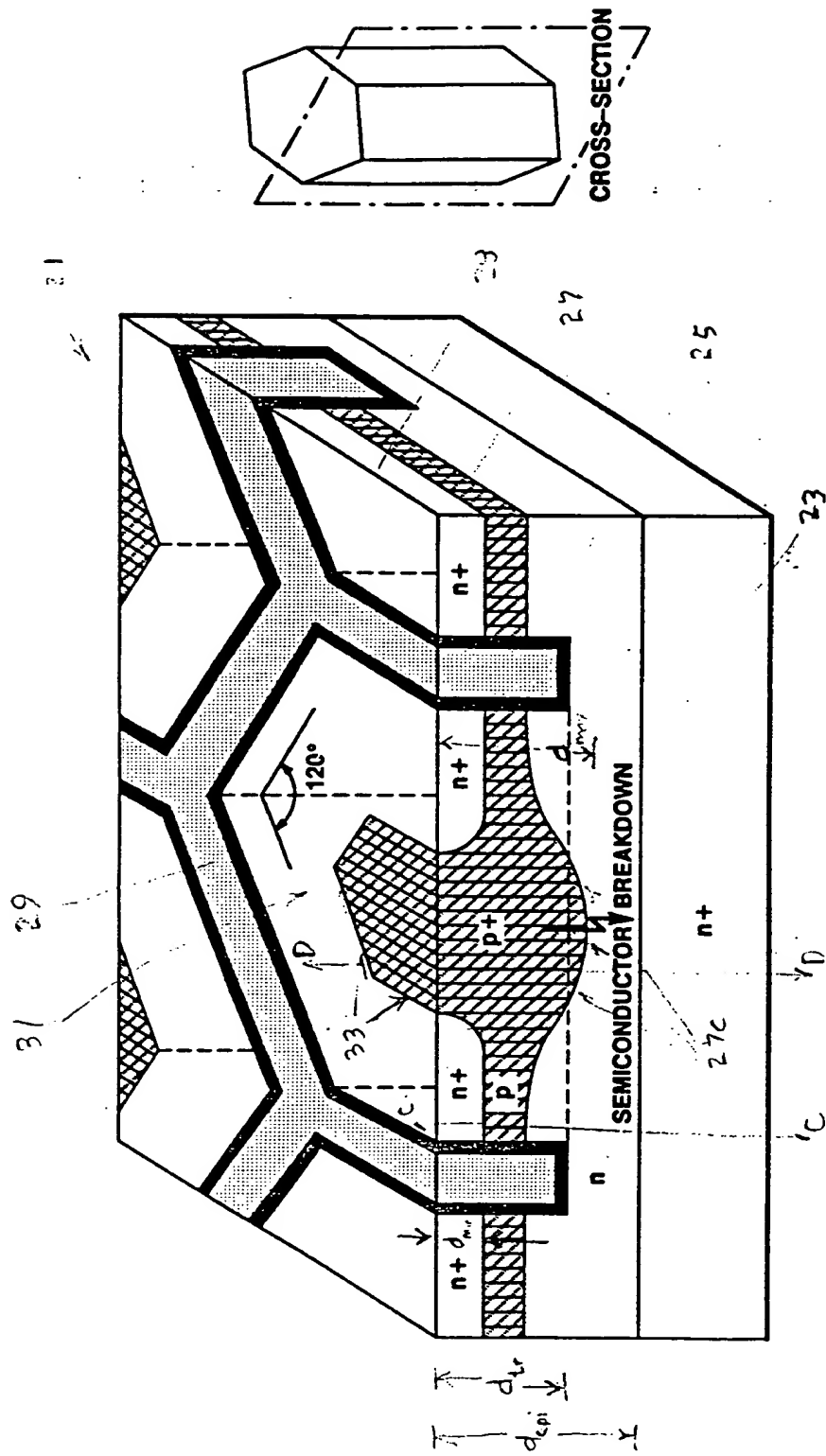
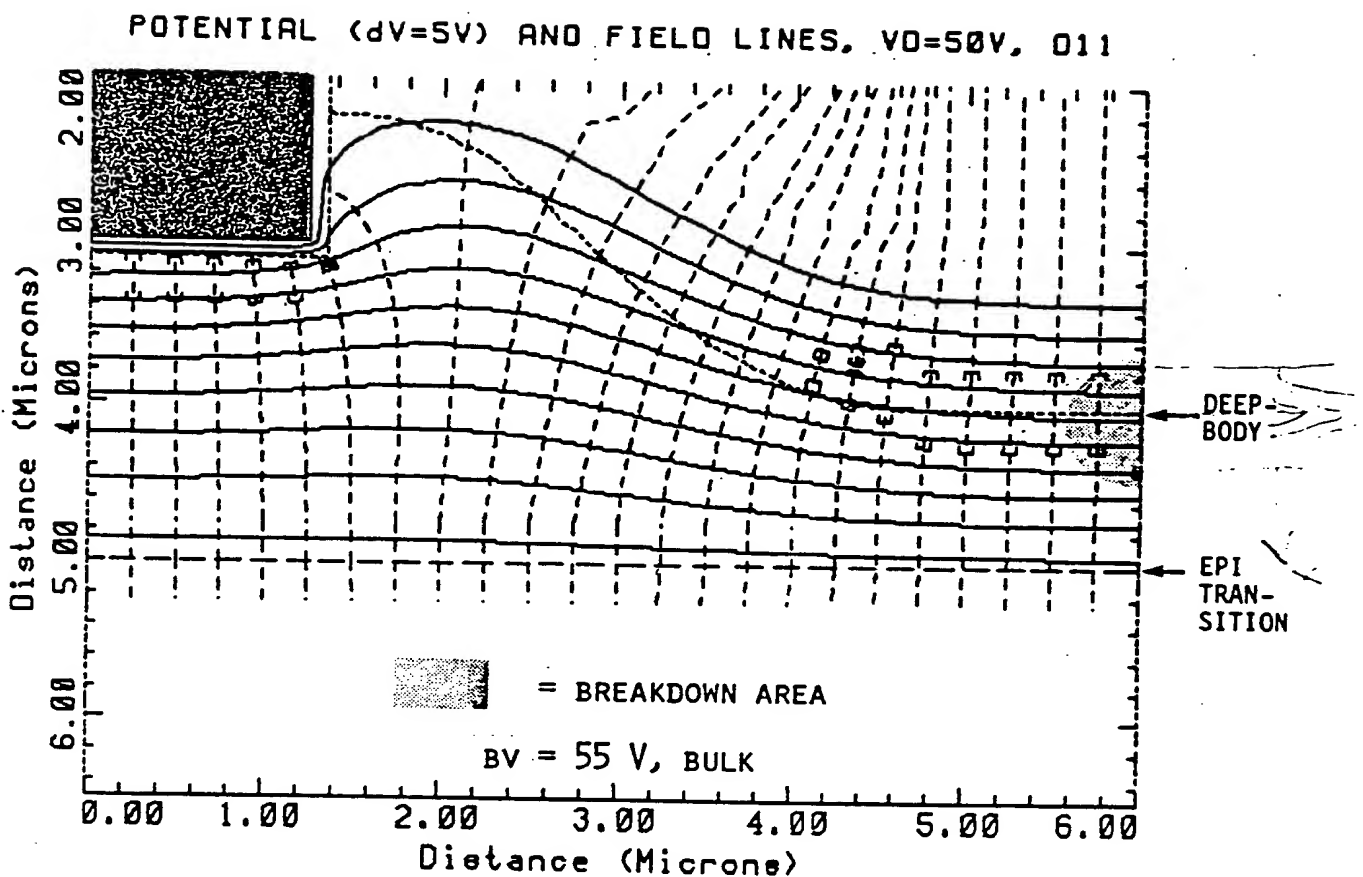


Figure 8

3-D representation of the optimized trench DMOS transistor cell proposed in this Patent Application.

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read & understood R. by D. L. August 11, 1988

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$\alpha_{eff} \frac{dy}{dx} = 1$ $\alpha_{eff} = \text{strong (exp.) funct. of } E$

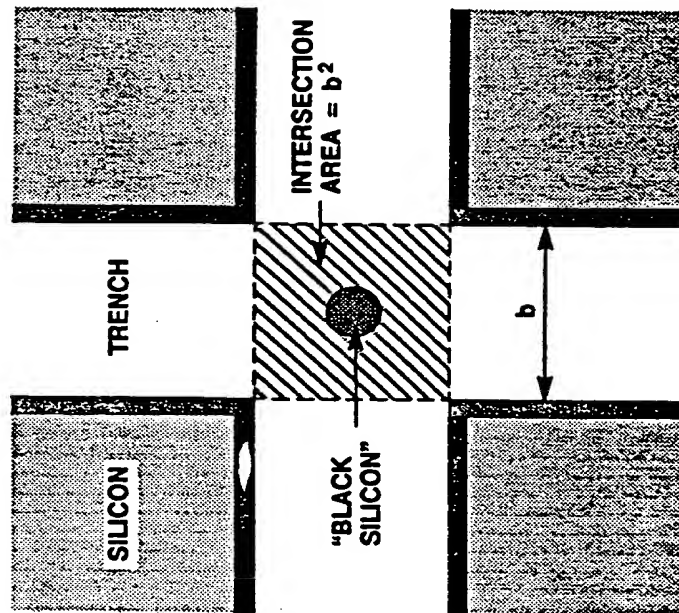
$\alpha_{eff} = A E^C - B/E$

Figure 9

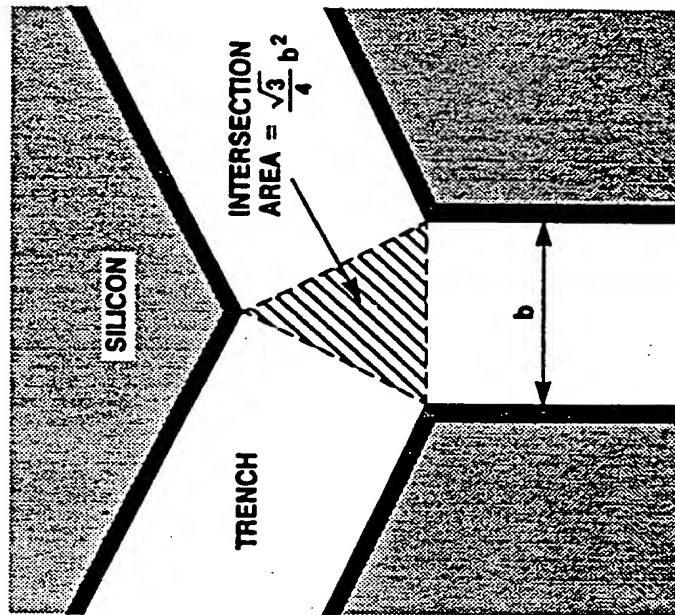
2-D computer simulation of the BVDSS operation of a trench MOS transistor having the deep body junction deeper than the trench. Drain breakdown takes place in the bulk.

read and understood R. K. W. A. August 10, 1988
read and understood R. K. W. A. August 4, 1988

"BLACK SILICON" COMPARISON



SQUARE CELLS



HEXAGONAL CELLS

Figure 10

Comparison of the "black silicon" areas at trench intersections:
square cell (left) versus hexagonal cell (right).

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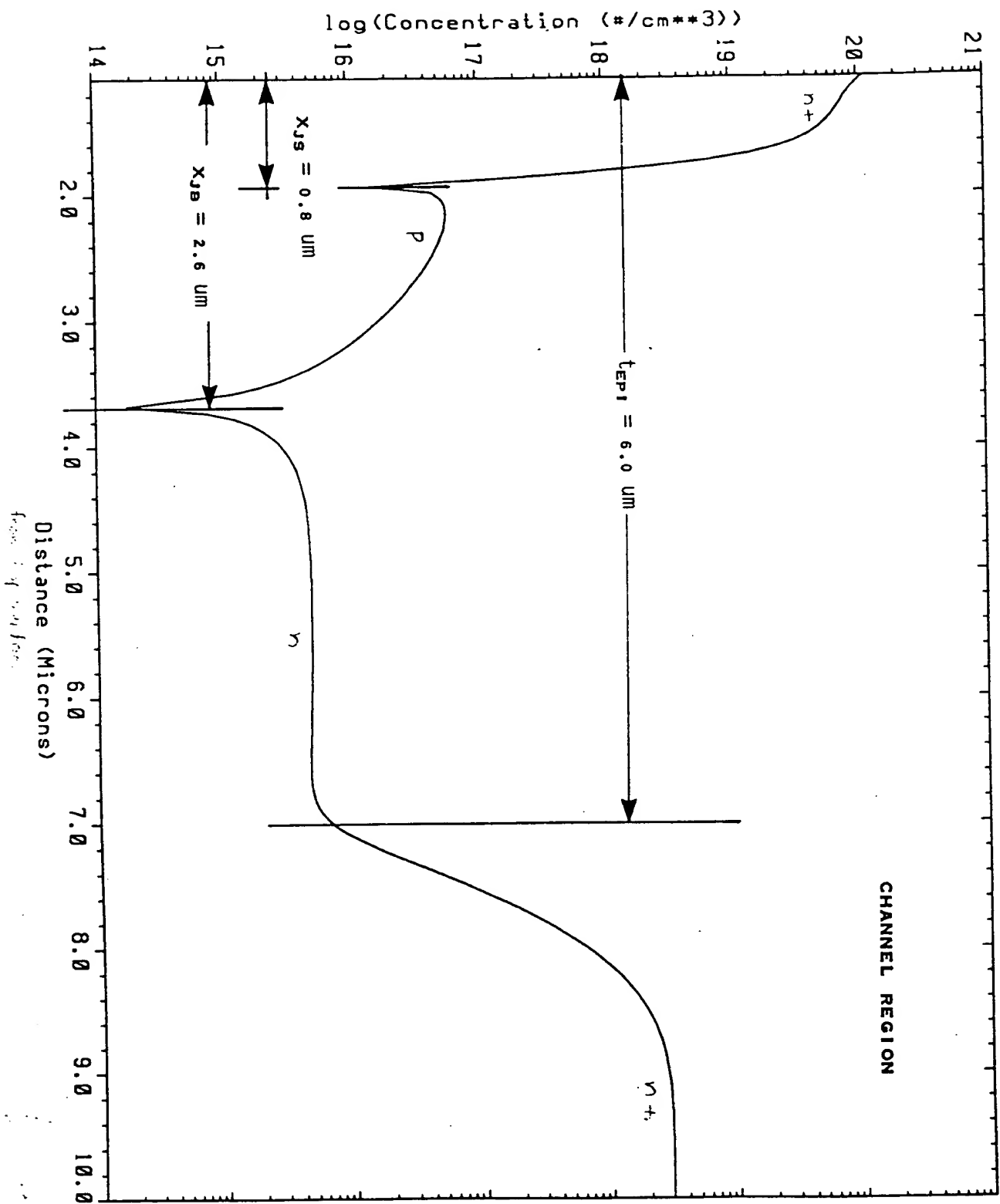


Fig 11

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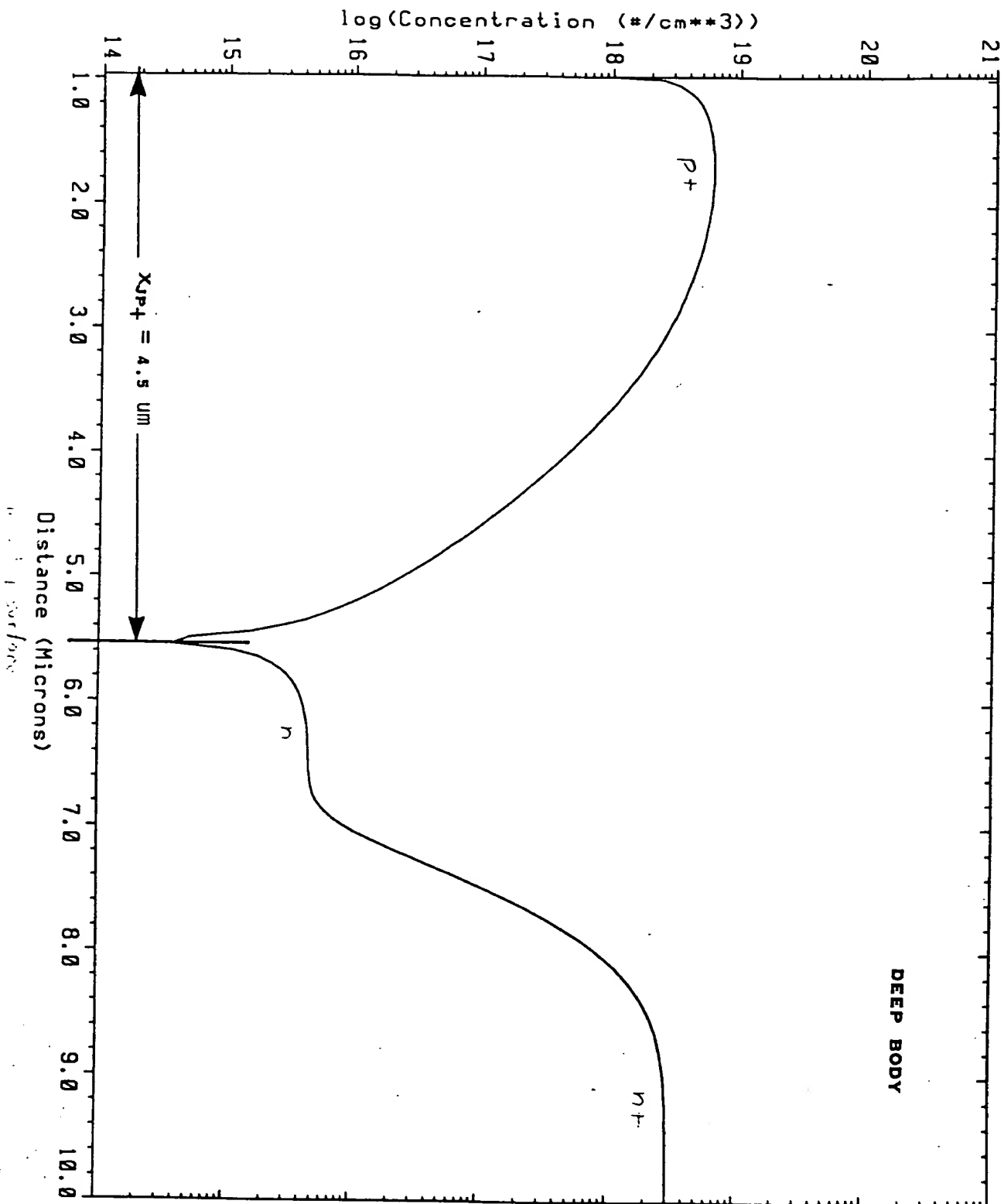
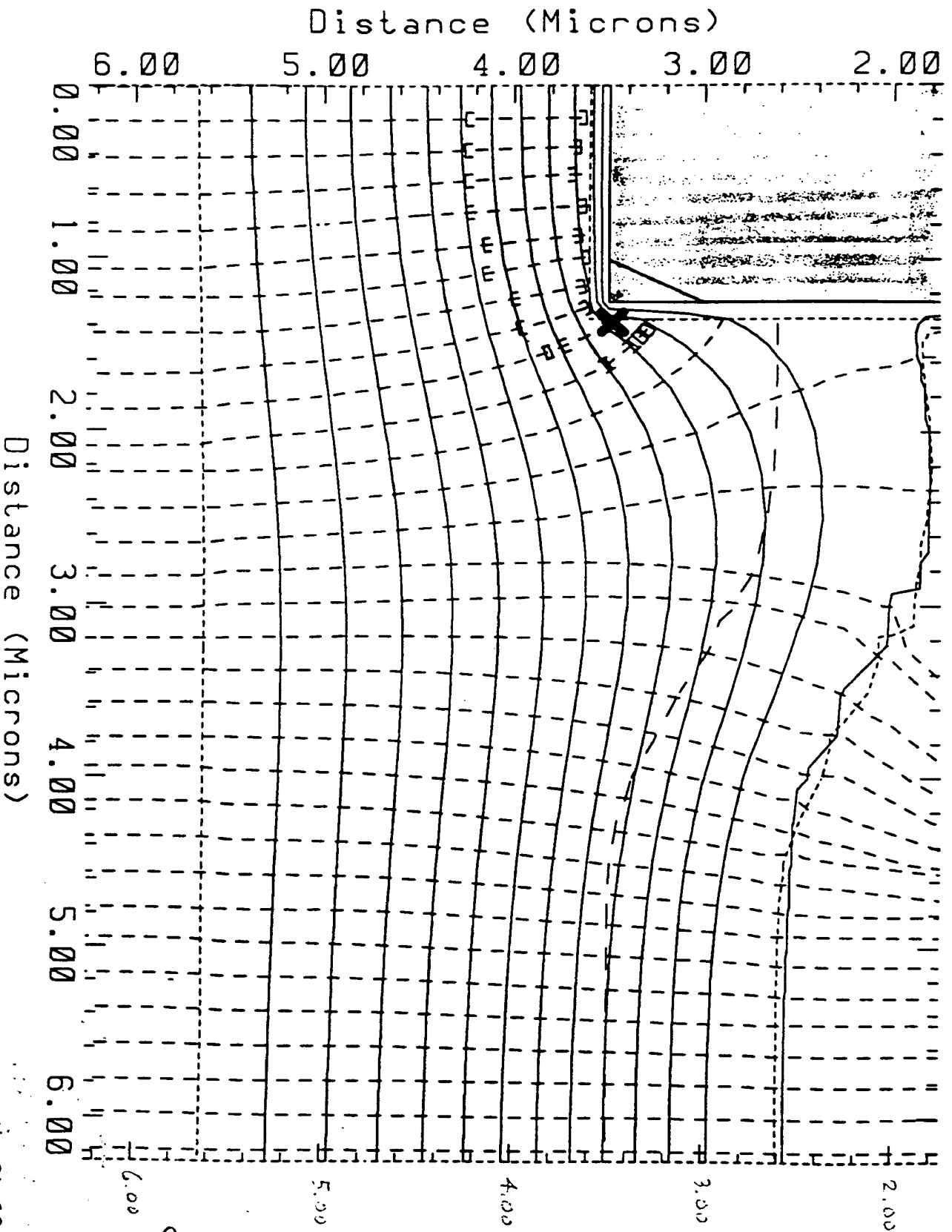


Fig. 12

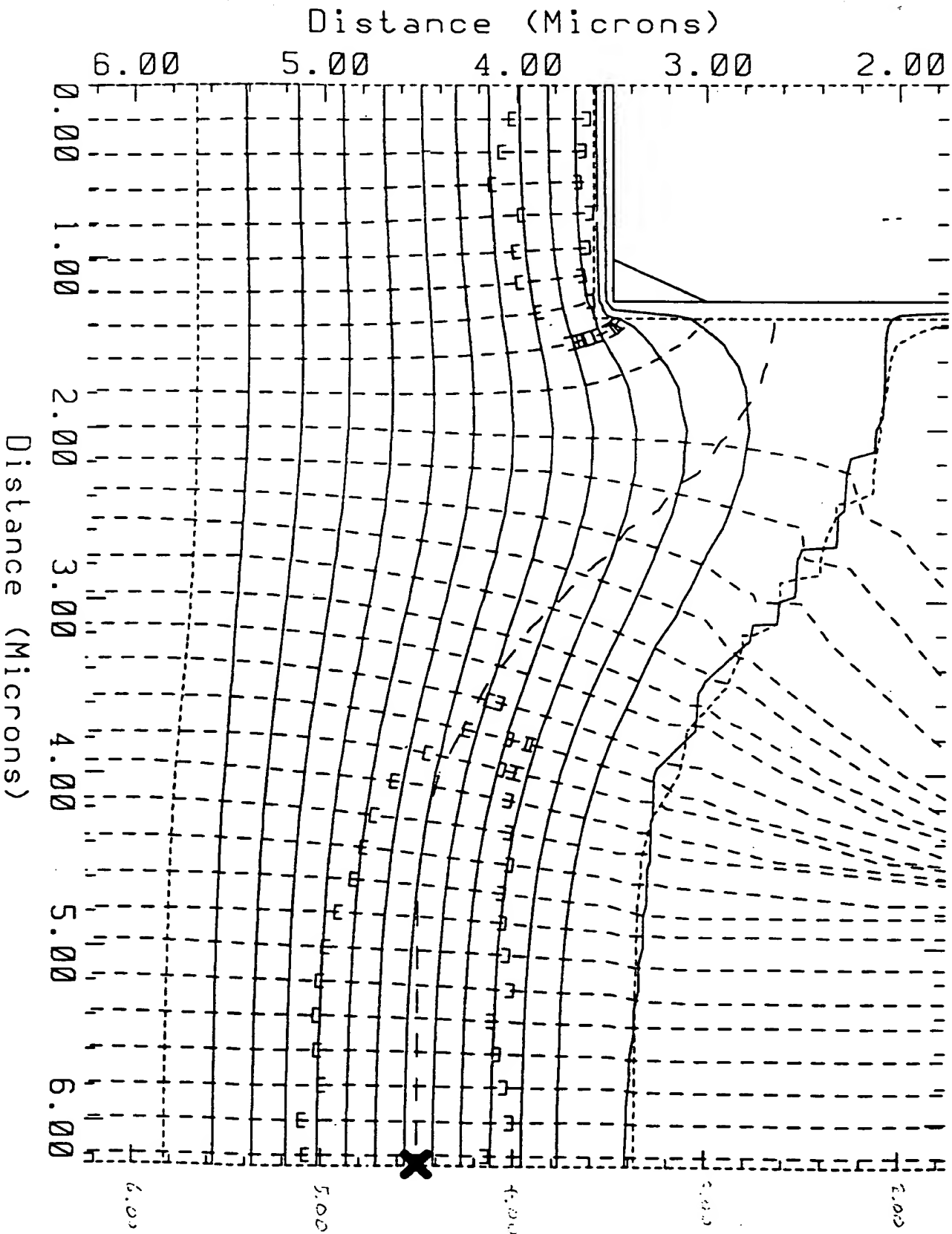
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ELECTRIC FIELD, $V_D=50V$, $dV=4.0V$, $E.MARK=2.5ESV/cm$ - G32J



BV = 64.19 V
SURFACE

926980/00
581851668

ELECTRIC FIELD, $V_D=50V$, $dV=4.0V$, $E.MARK=2.5ESV/cm$ - G32BV = 61.81 V
BULK

08/158180

VD=50V, DV=4.0V, E.MARK=2.5E5V/cm - G321

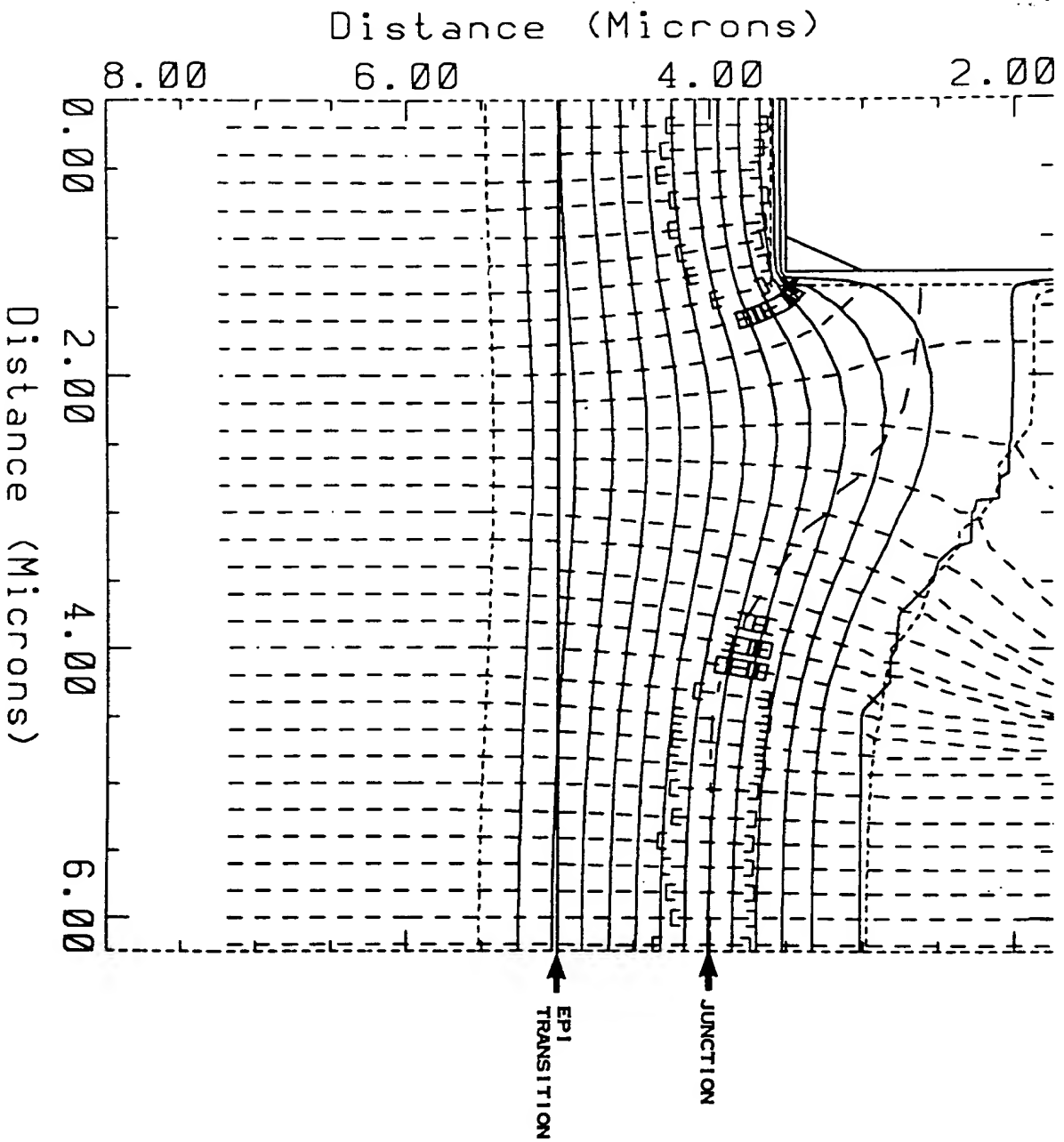


FIG 16

BV = 61.25 V
SURFACE

809/58/89

00/086976
08/85/608

VD=50V, dV=4.0V, E.MARK=2.5E5V/cm - G32m

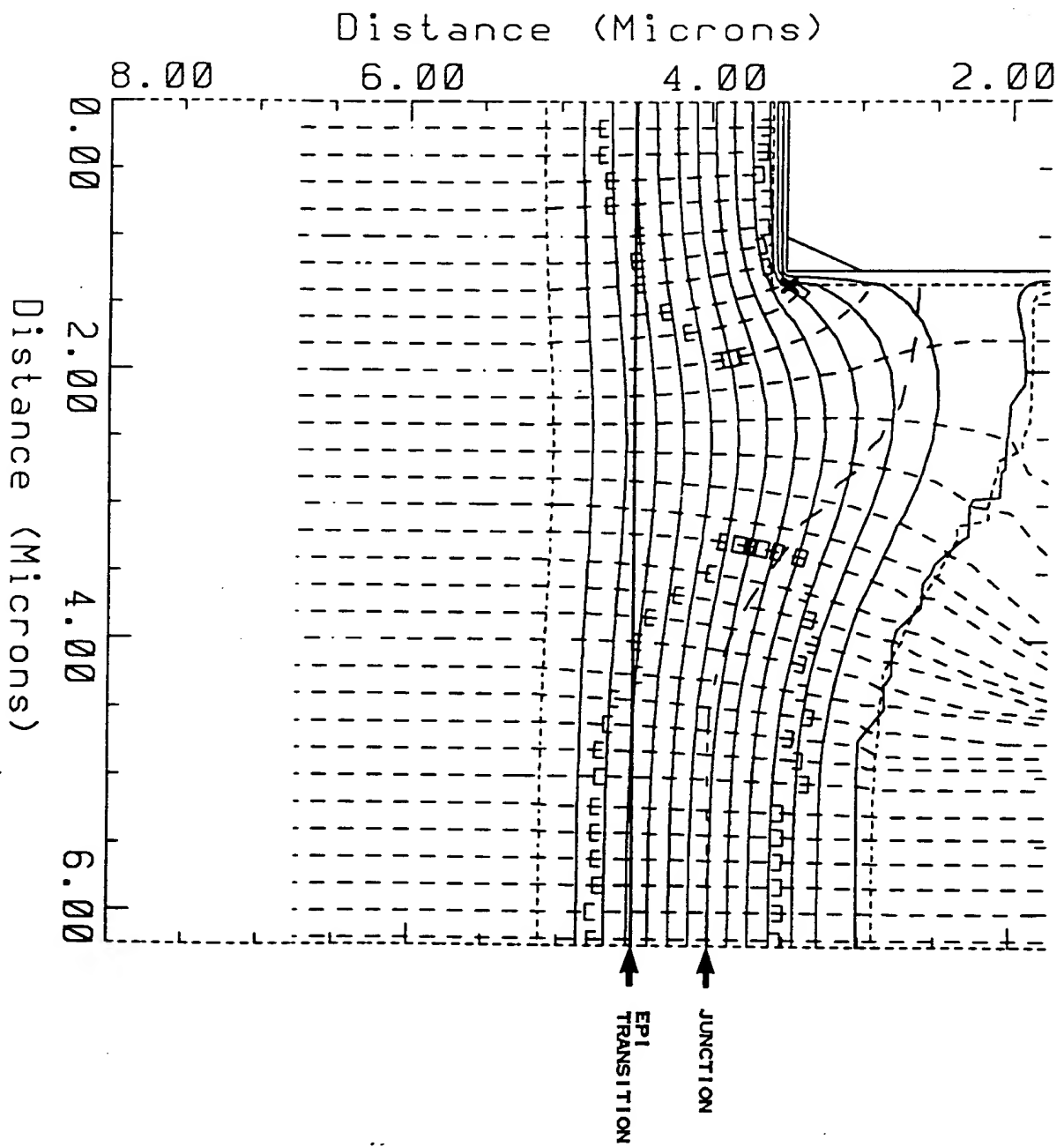


FIG. 17

BV = 52.67 V
SURFACE

$V_D = 50V$, $dV = 4.0V$, $E. MARK = 2.5E5V/cm$ - G32a

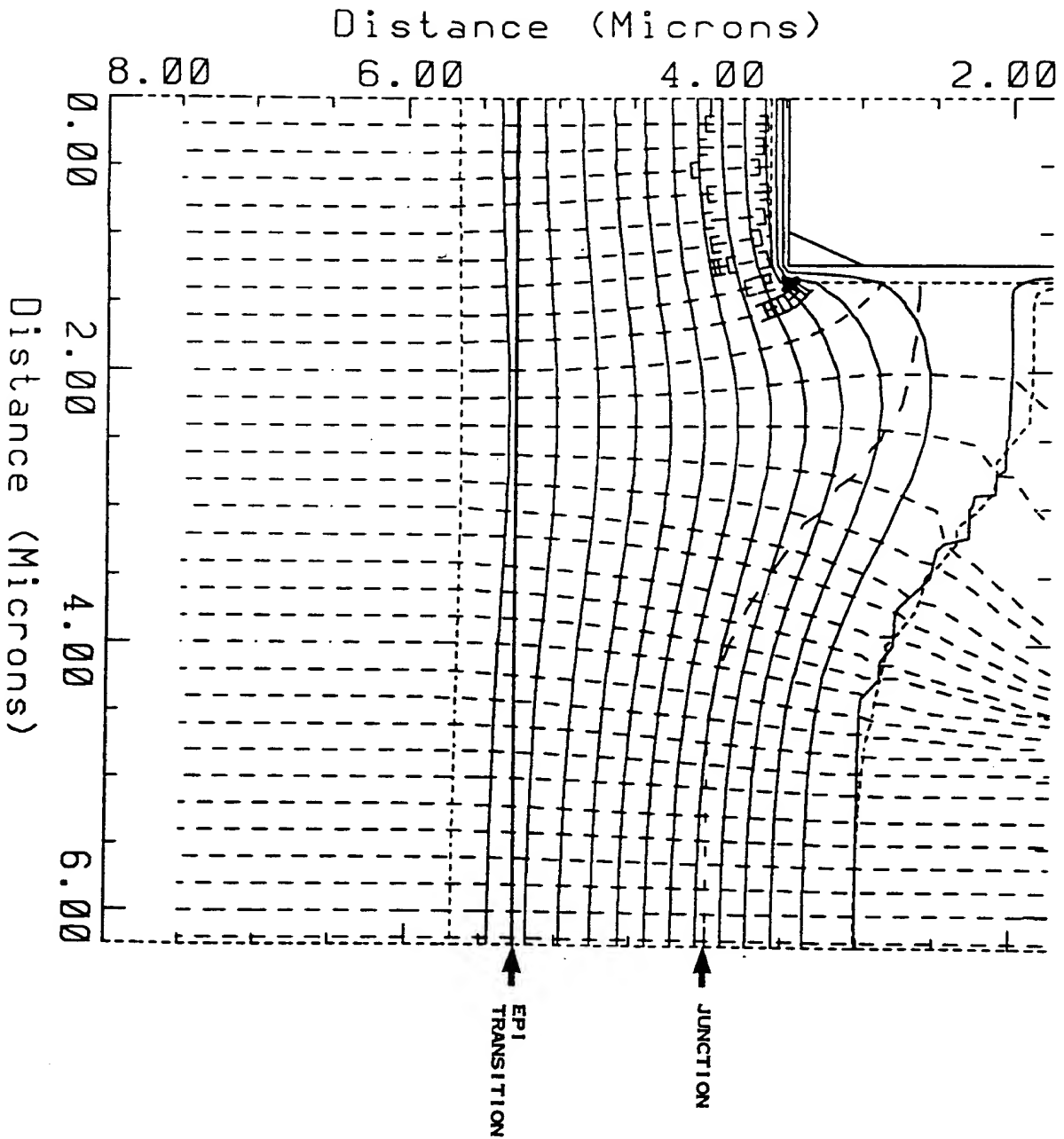


FIG. 18

$BV = 67.46V$
SURFACE

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VD=50V, dV=4.0V, E.MARK=2.5E5V/cm - G32z

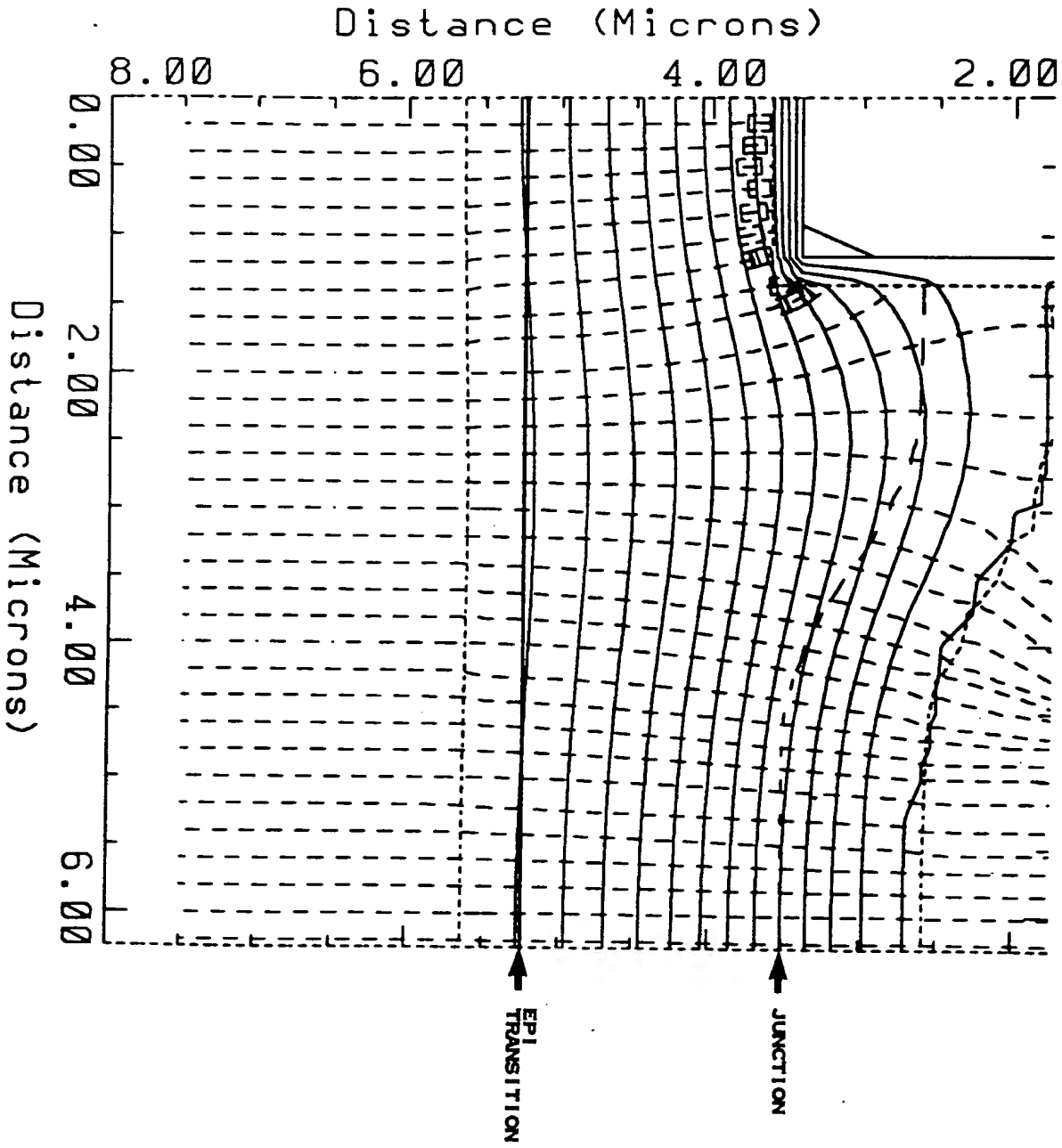


FIG. 19

BV = 74.93 V
SURFACE

VD=50V, dV=4.0V, E.MARK=2.5E5V/cm - G32w

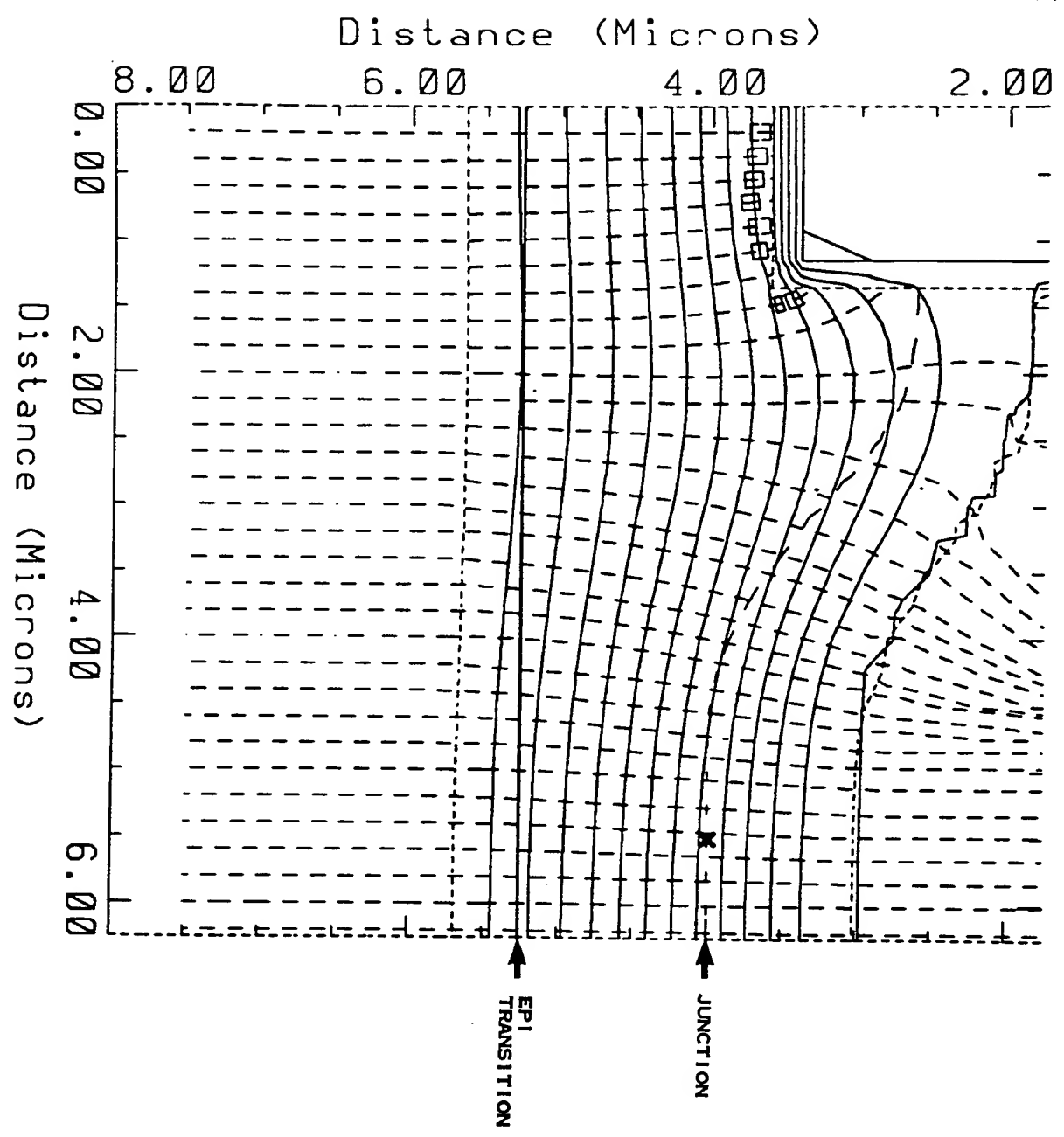


FIG. 20

BV = 69.53 V
BULK

08/98/80

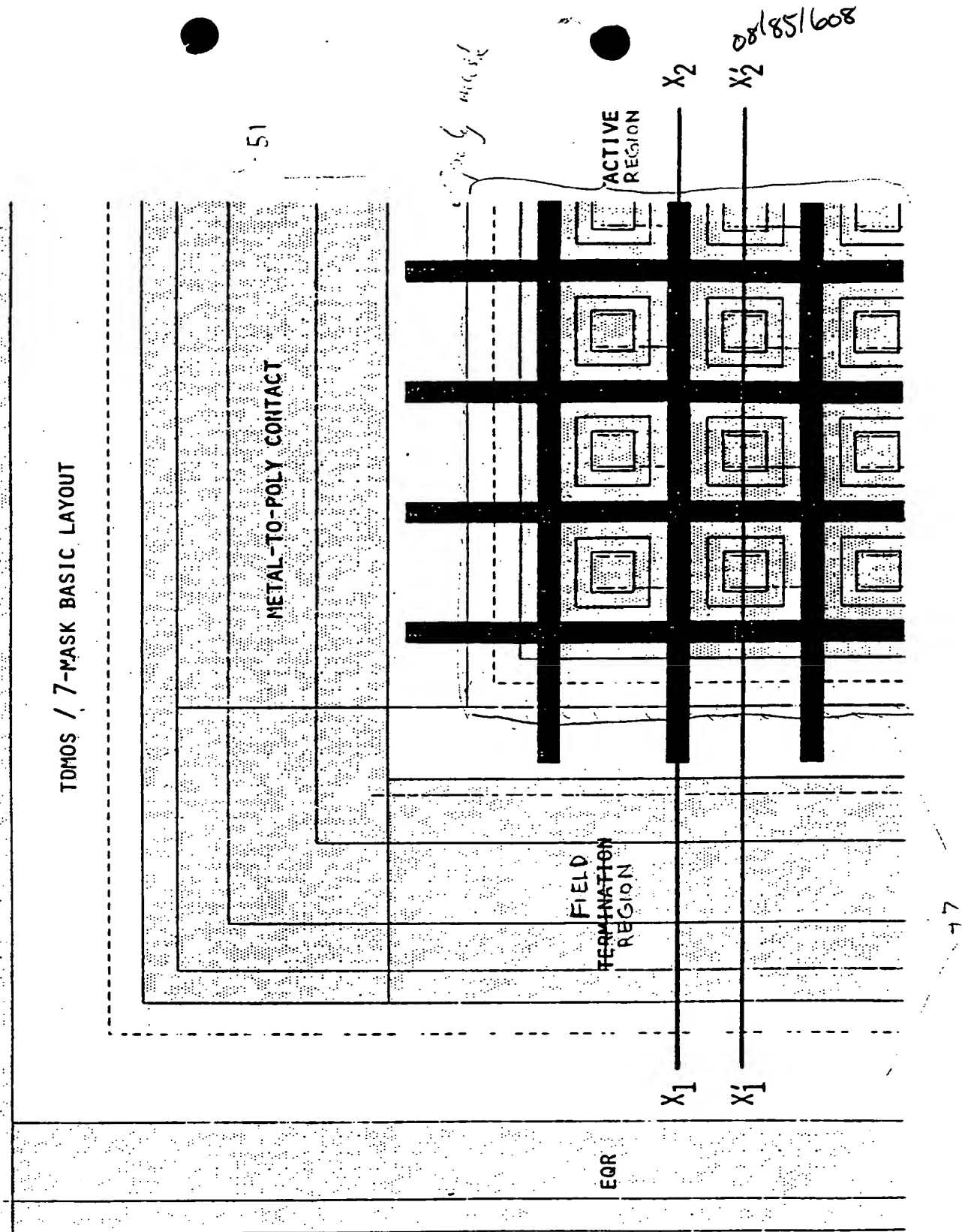


Fig. 21

read and understood QK will August 10, 1988
 read and understood Randolph D. M. August 11, 1988

read and understood Q2/KWA August 10, 1988
 read and understood Randolph D. Del August 4, 1988

7-MASK TDMOS - PROCESSING BLOCK 1

n/n + EPI → POST-EPI OXIDATION → MASK 1 = DEEP BODY → BORON IMPLANT & DIFFUSION / OXIDATION →

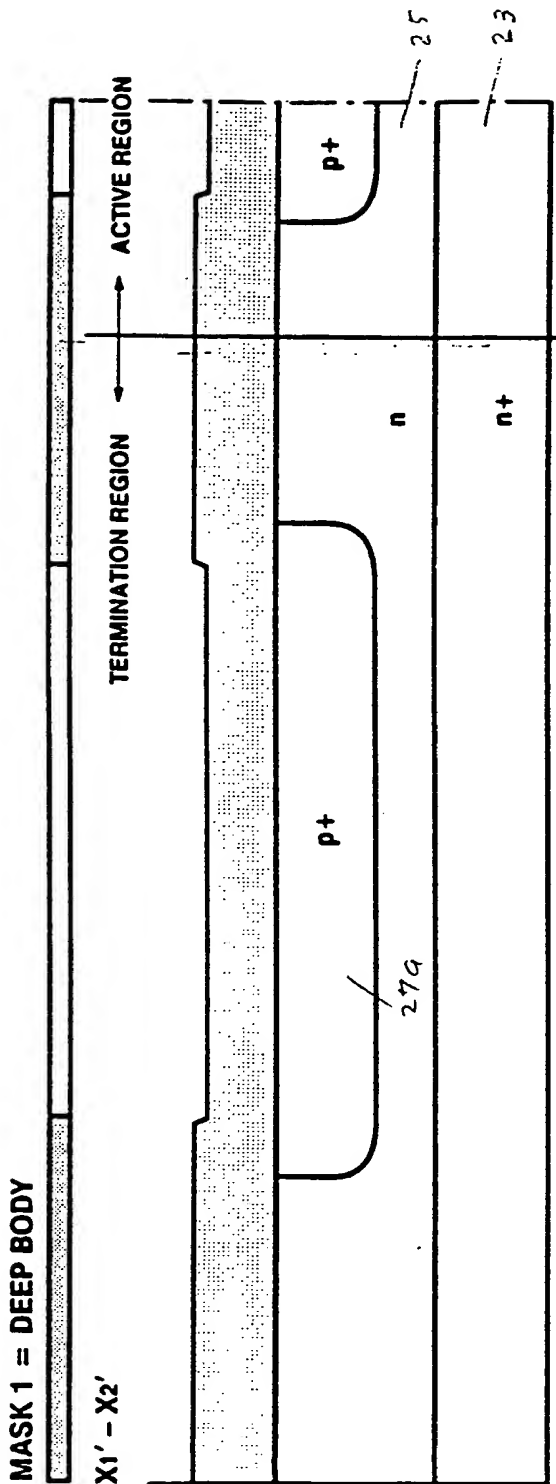


Fig. 22A

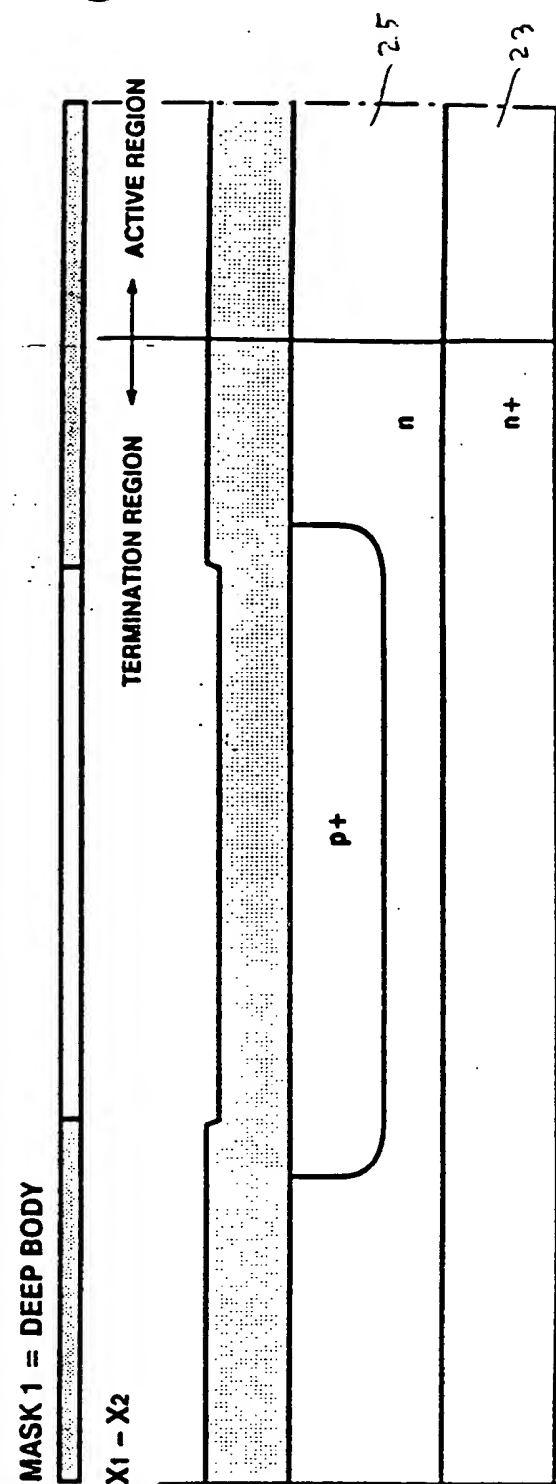


Fig. 22B

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7-MASK TDMOS - PROCESSING BLOCK 2

→ MASK 2 = ACTIVE → BORON IMPLANT & DIFFUSION / OXIDATION → ARSENIC IMPLANT & DIFFUSION / OXIDATION → LTO DEPOSITION

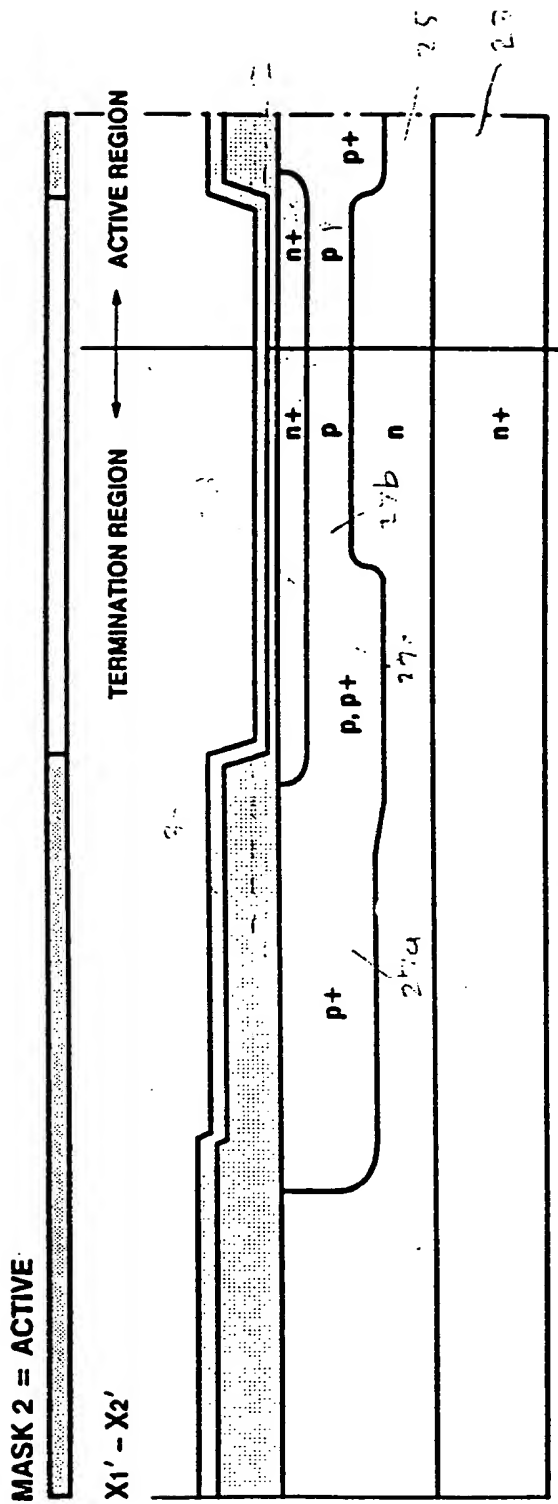


Fig. 23A

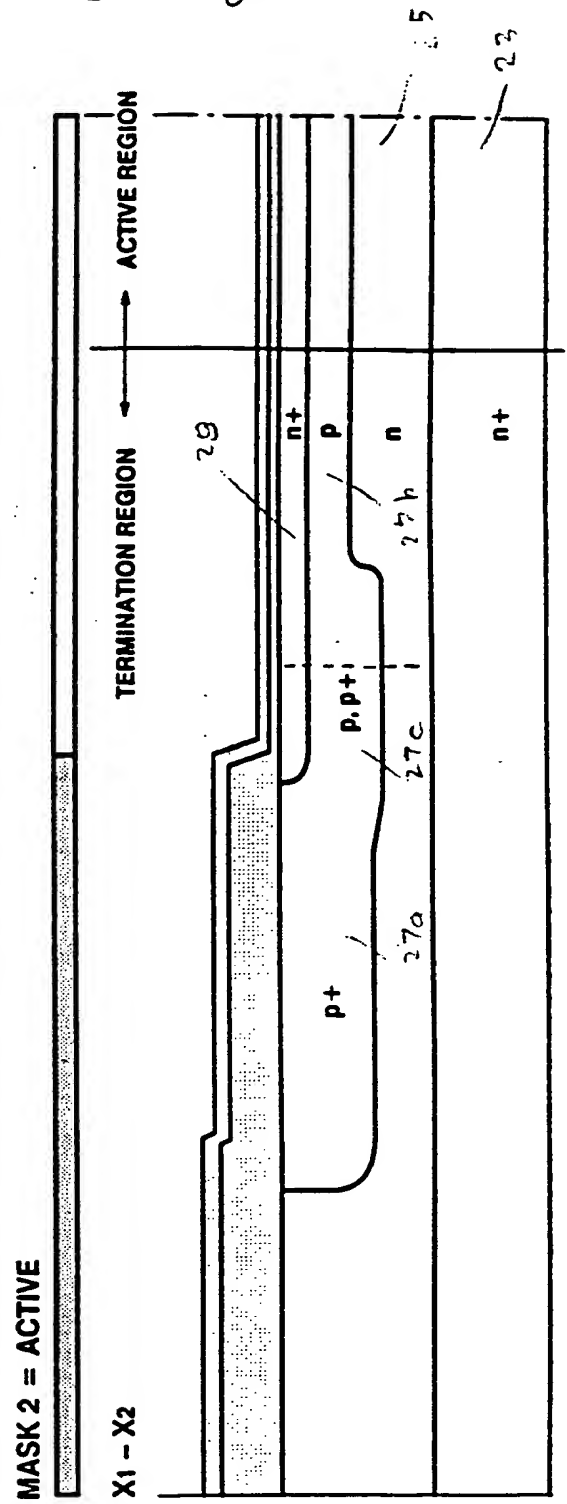


Fig. 23B

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read and understood Paul Hoff Drel August 11, 1988

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7-MASK TDMOS - PROCESSING BLOCK 3

→ MASK 6 = TRENCH → TRENCH DRY ETCHING →

MASK 6 = TRENCH

X1' - X2'

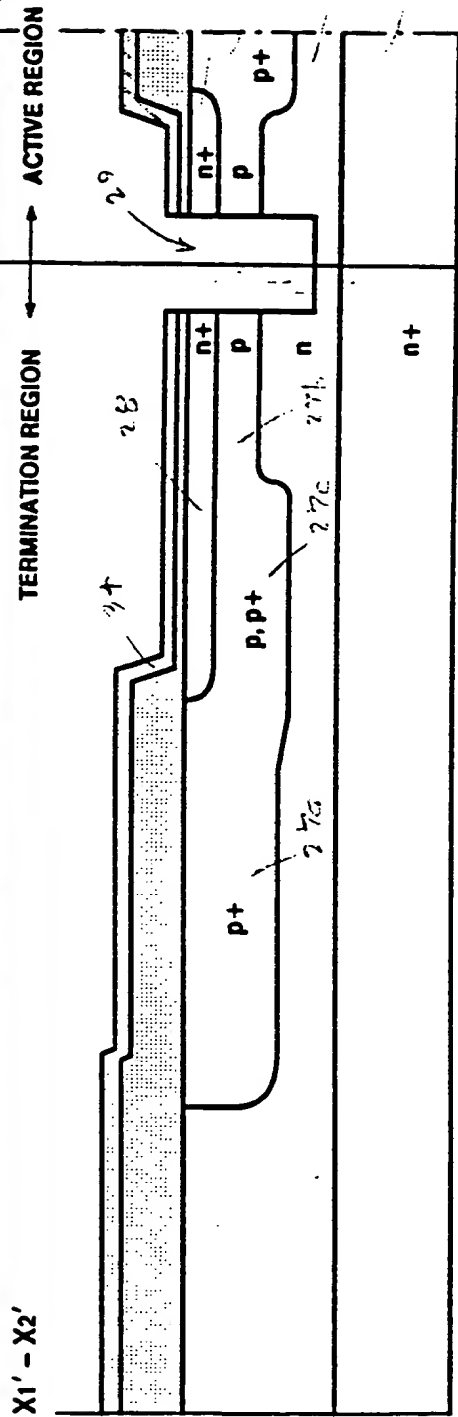


Fig. 24A

MASK 6 = TRENCH

X1 - X2

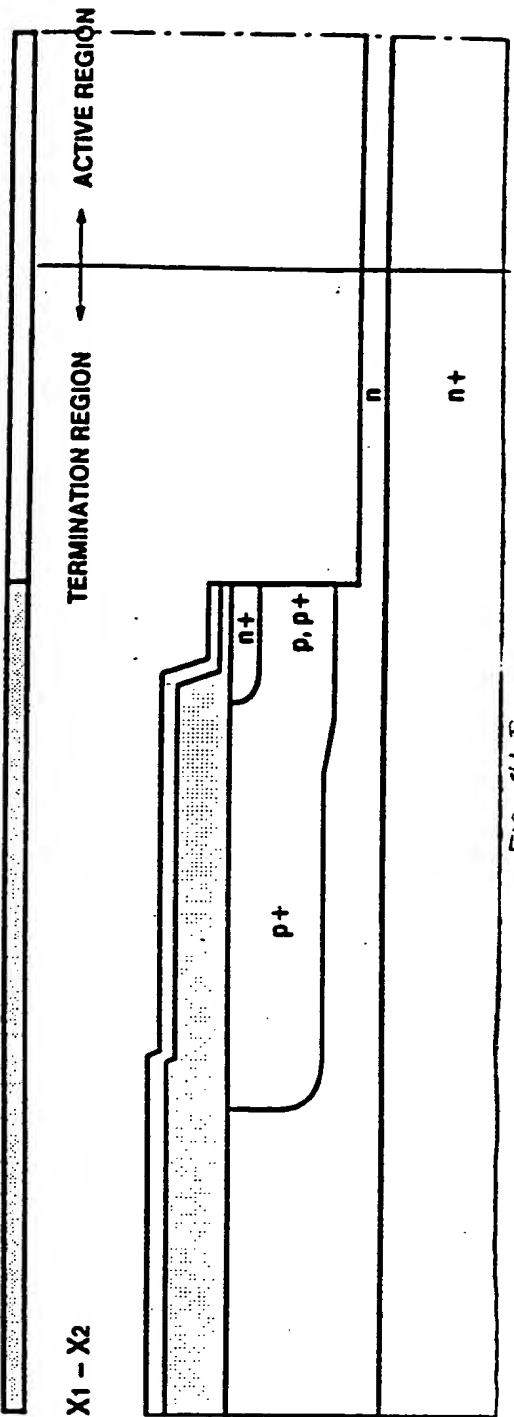


Fig. 24B

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7-MASK TDMOS - PROCESSING BLOCK 4

→ SACRIFICIAL OXIDATION & ETCHING → GATE OXIDATION →

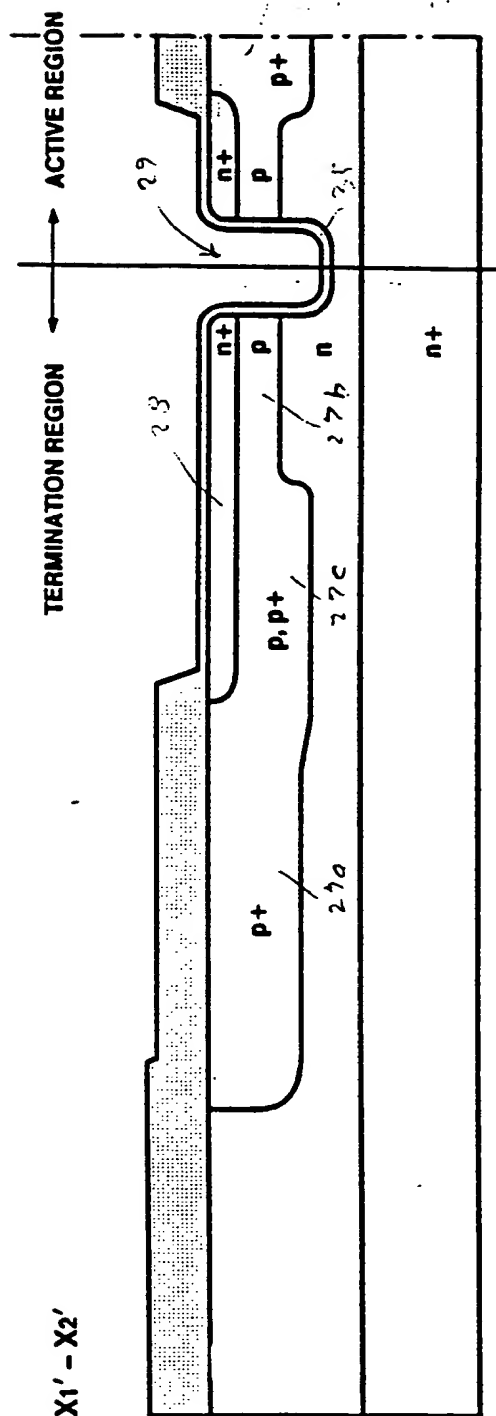


Fig. 25A

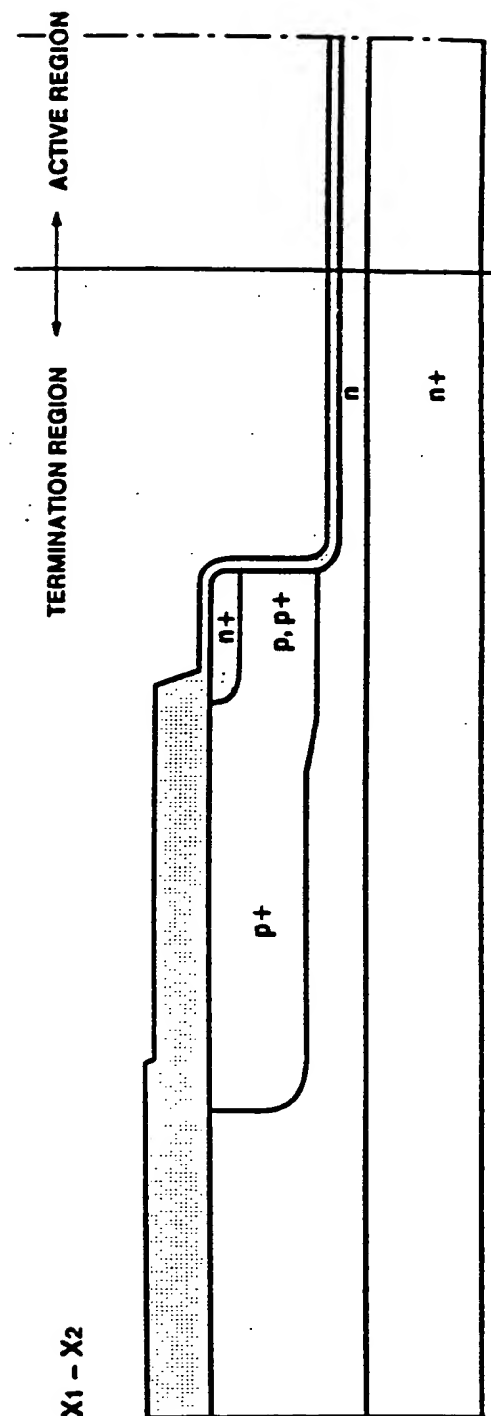


Fig. 25B

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read and understood Randolph M August 11, 1988

7-MASK TDMOS - PROCESSING BLOCK 5

 FIRST POLY DEPOSITION & PHOSPHORUS DOPING
  OXIDATION (ETCH STOP)
 

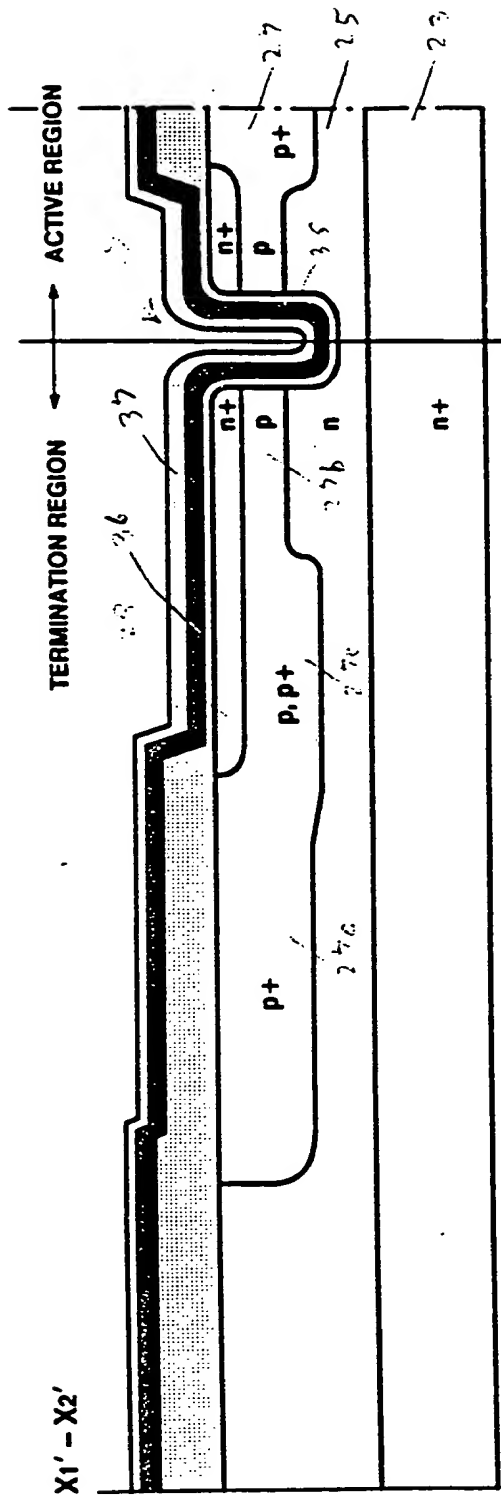


Fig. 26A

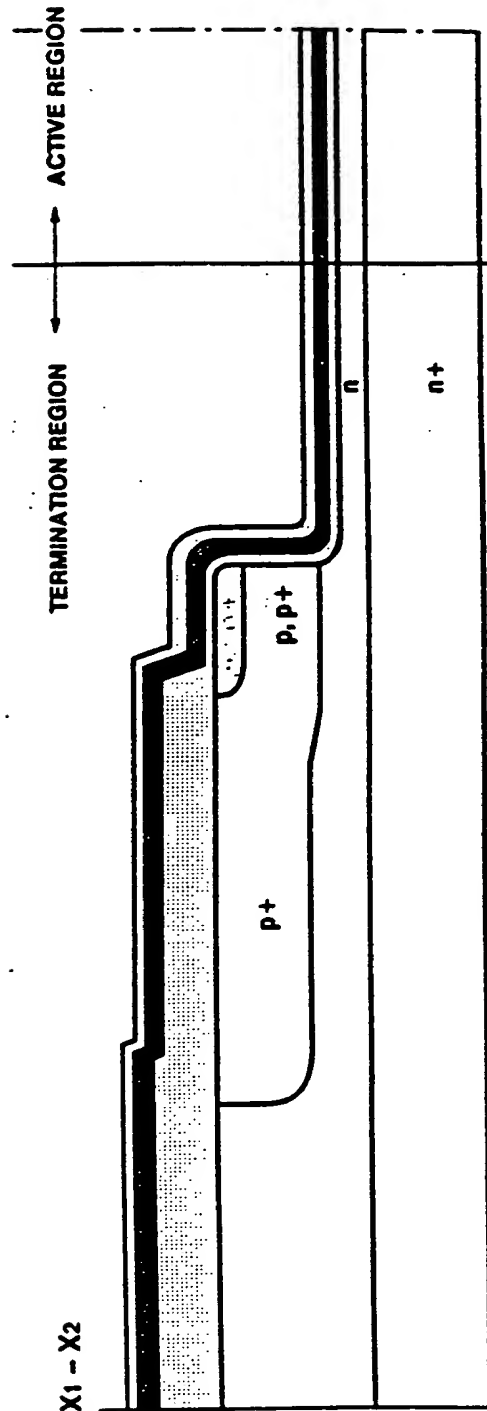


Fig. 26B

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 read and understood Darlegh D. led August 11, 1988

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7-MASK TDMOS -- PROCESSING BLOCK 6

→ SECOND (UNDOPED) POLY DEPOSITION →

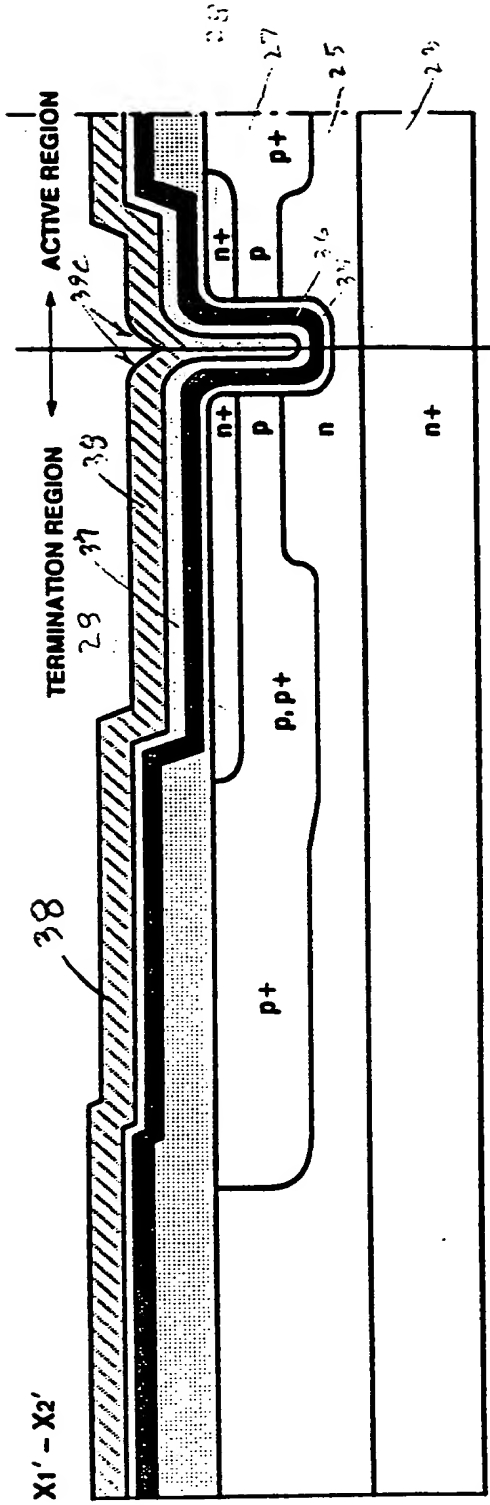


Fig. 27A

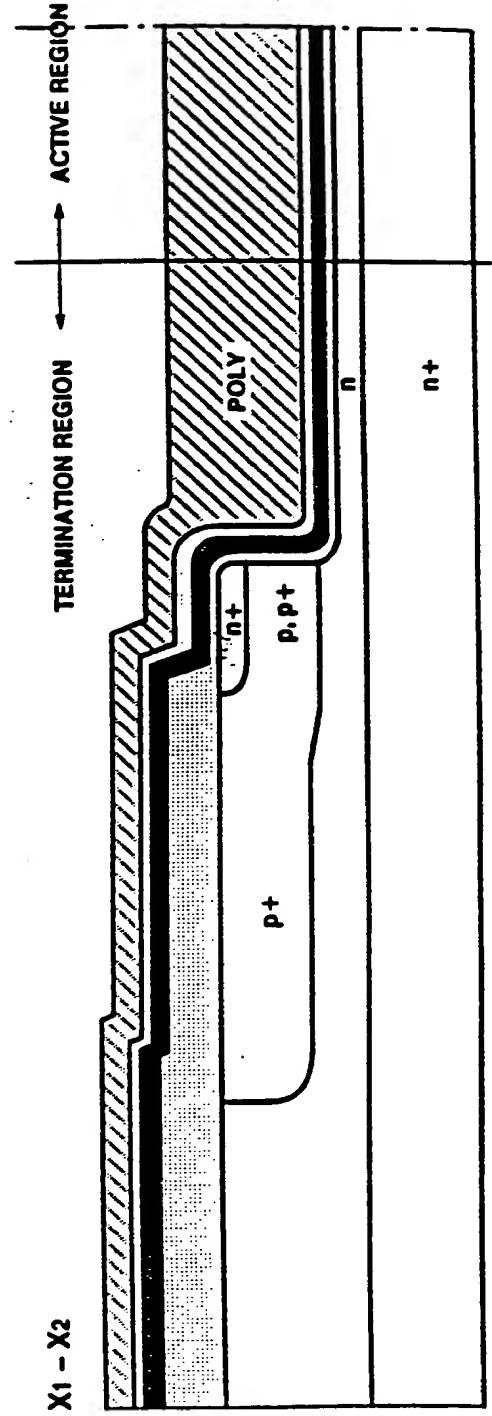


Fig. 27B

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read & understood QKWA August 10, 1988
read and understood Randolph D. Lehn August 11, 1988

7-MASK TDMOS - PROCESSING BLOCK 7

→ POLY PLANARIZATION ETCHING → ETCH-STOP-OXIDE STRIP →

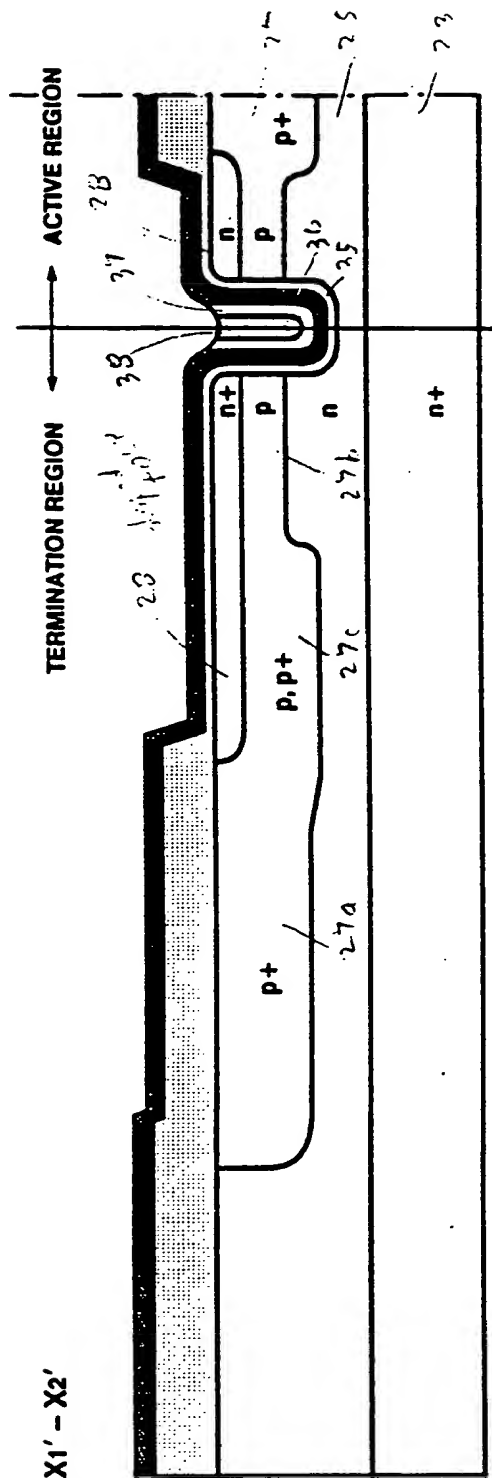


Fig. 28 A

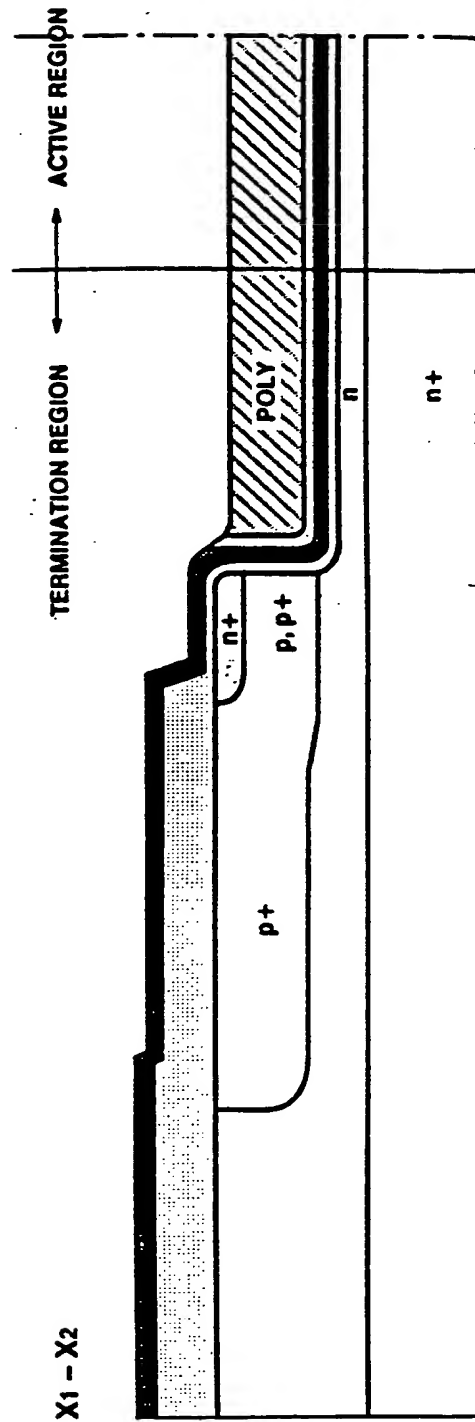


Fig. 28 B

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read & understood QKWJH August 10, 1988
read and understood Paulab QKWJH August 11, 1988

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7-MASK TDMOS - PROCESSING BLOCK 8

➔ MASK 7 = POLY ➔

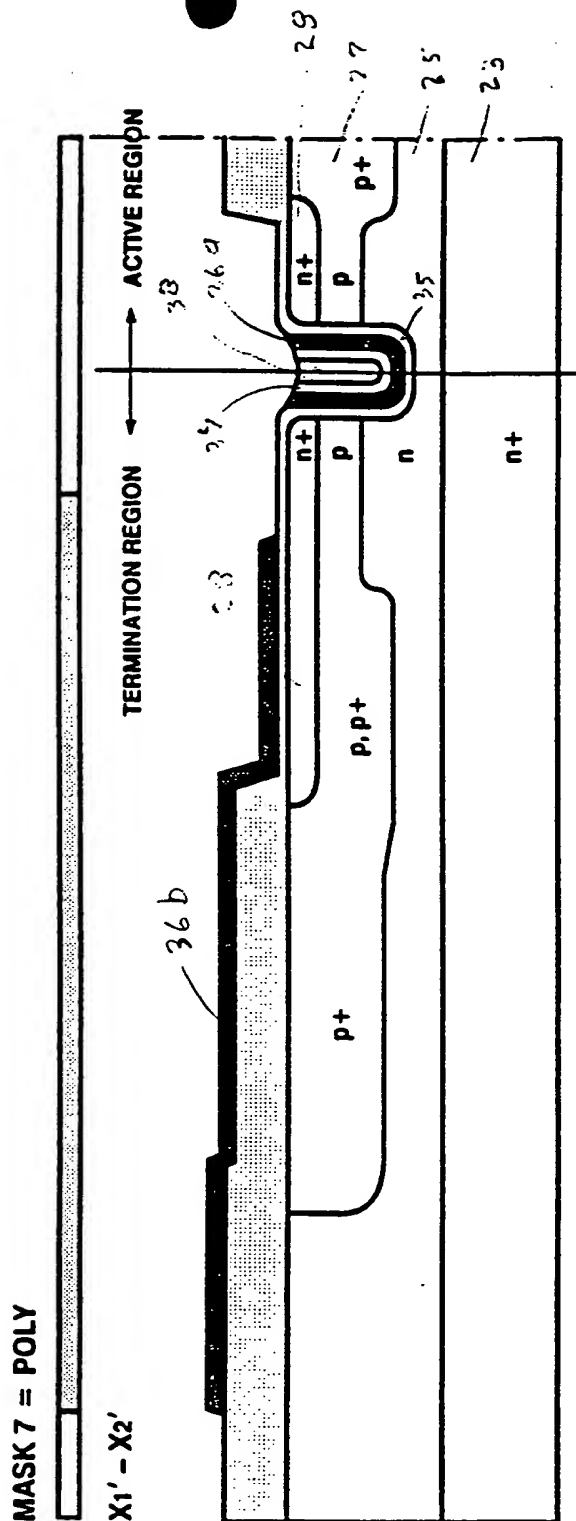


Fig. 29A

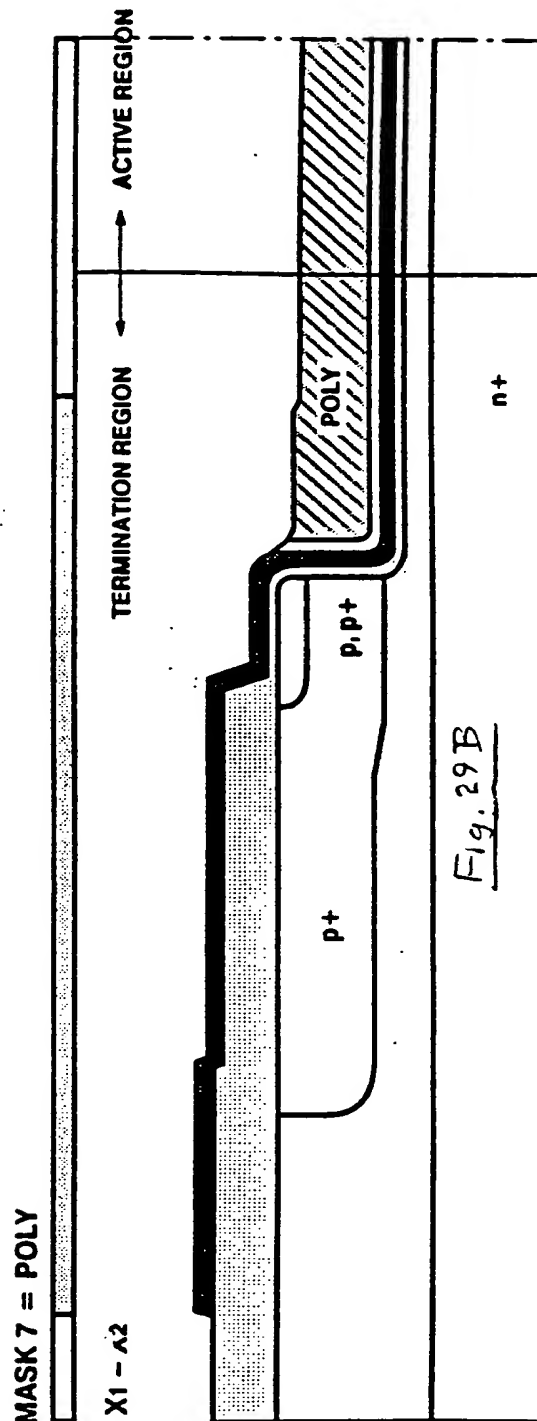


Fig. 29B

08/851608

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read and understood Randolph A. Lee August 11, 1988

OXIDATION → BPSG DEPOSITION & FLOW → MASK 8 = CONTACT → BPSG REFLOW →

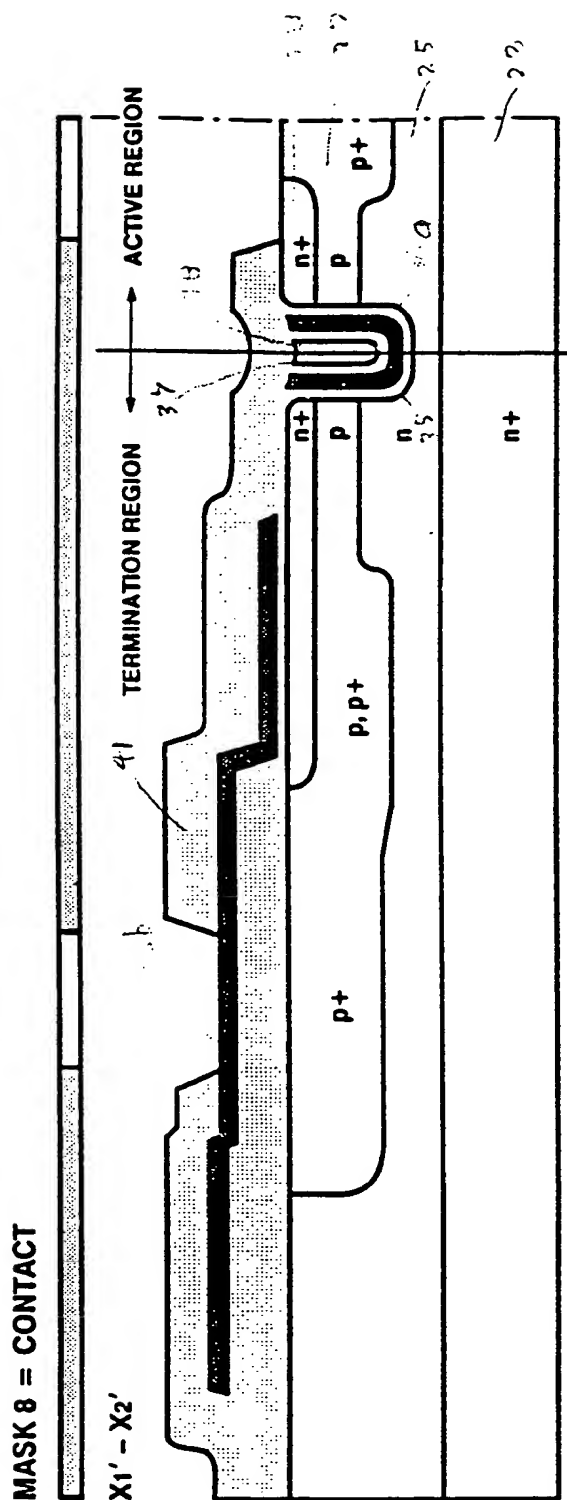
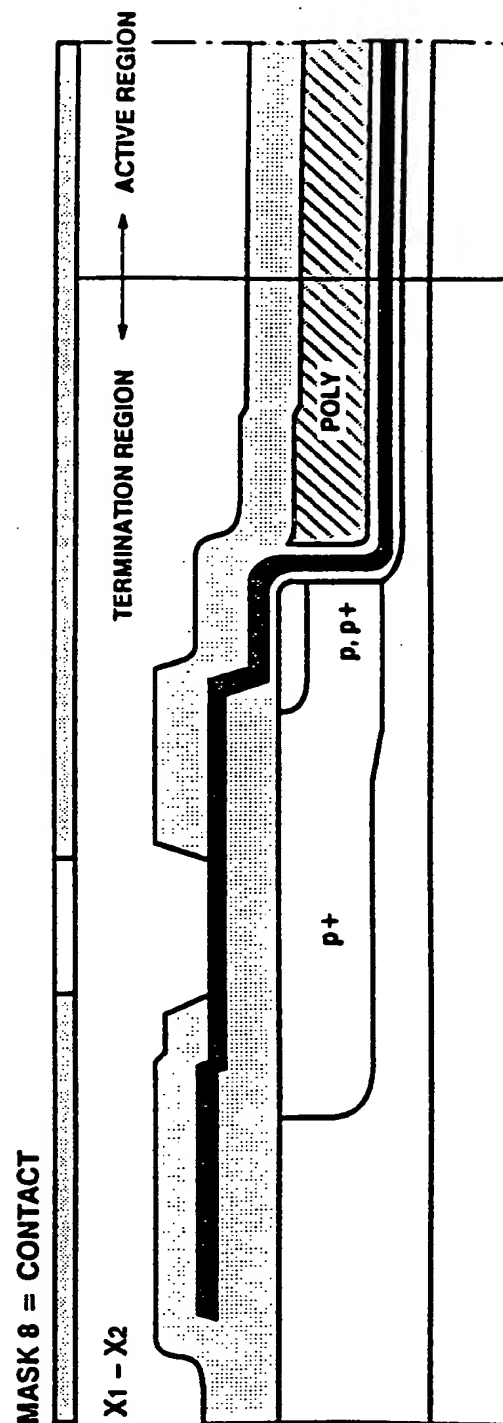


Fig. 30 A



rec'd & und., to: D. K. W. August 10, 1988
rec'd and understood Paul D. W. August 11, 1988

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↑ ALUMINUM DEPOSITION ↑ MASK S = METAL ↑ METAL ALLOYING ↑ ELECTRICAL CHECK ↑

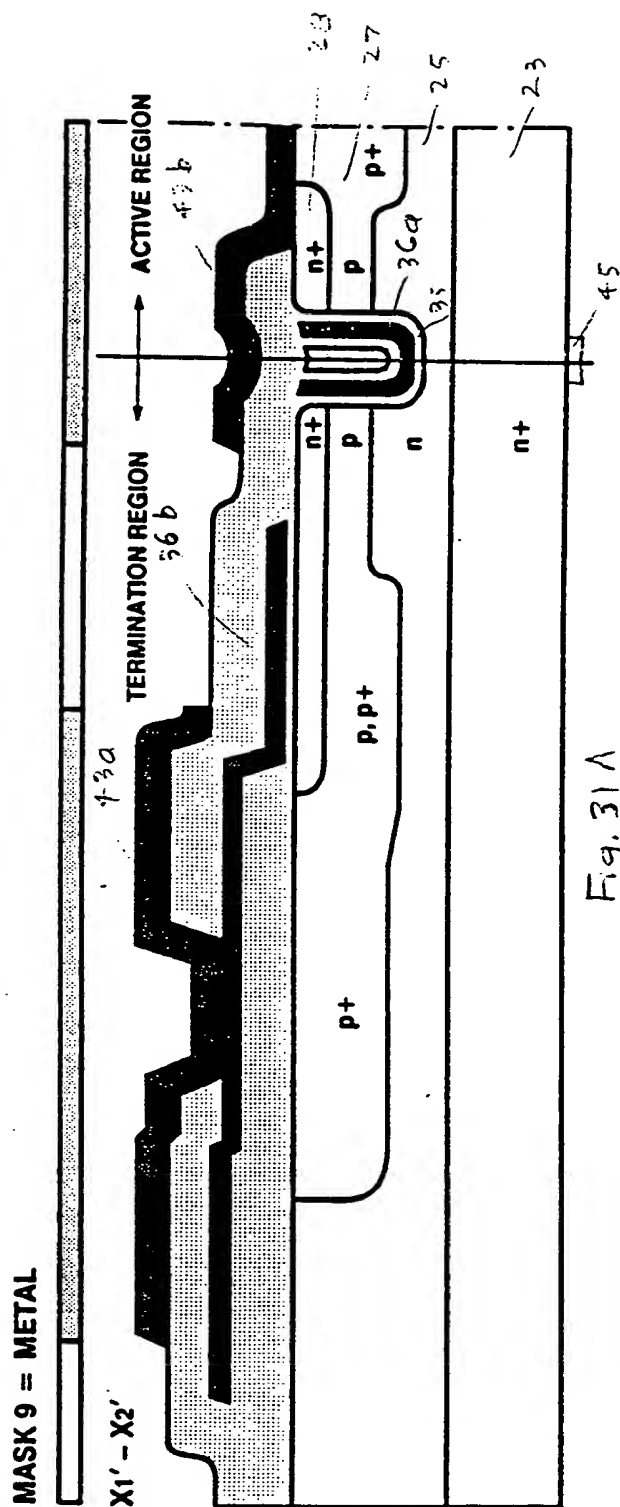
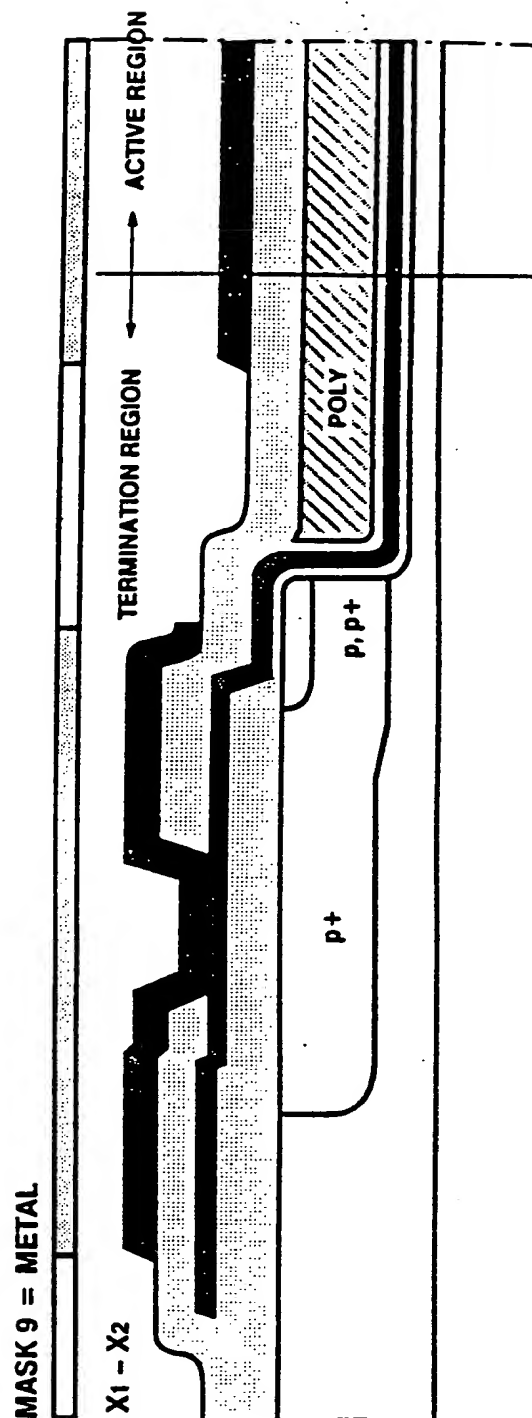


Fig. 31A



read & understood G & W on August 10, 1988
read and understood Randolph on August 11, 1988

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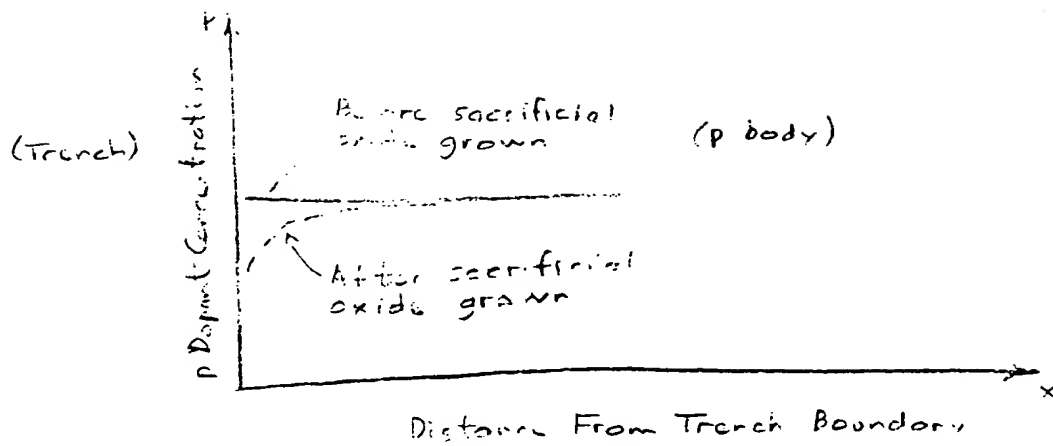


FIG. 32

DEVICE, RDSON SIMULATION - G32

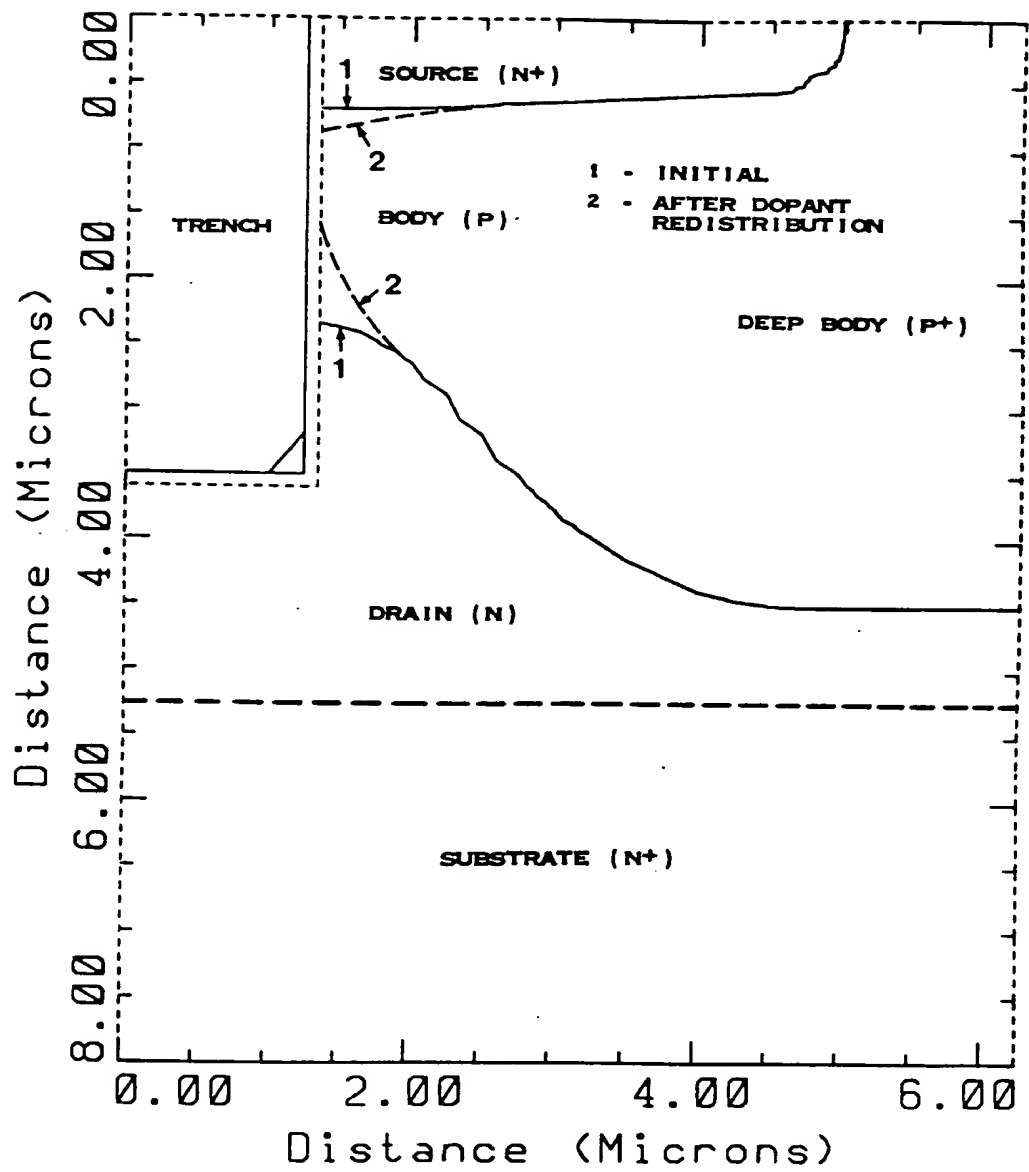


FIG. 33

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